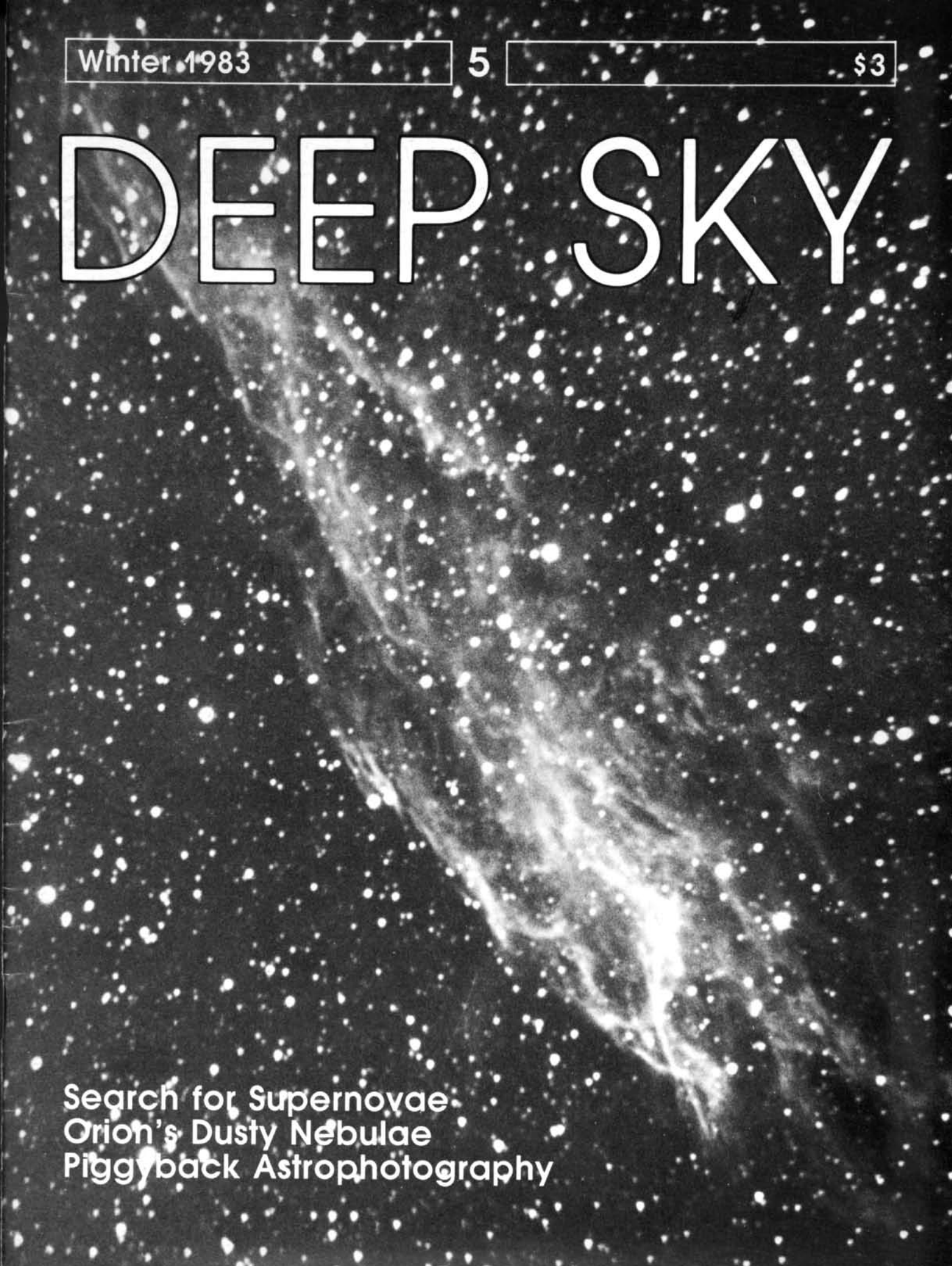
Winter 1983 5 $3

DEEP SKY



Search for Supernovae
Orion's Dusty Nebulae
Piggyback Astrophotography

ACS 450
THE ABSOLUTE SYSTEM

THE ASKO COMPUTERIZED CASSEGRAIN REFLECTING TELESCOPE DEPICTED IN THIS AD EXTENDS A COMBINATION OF PRECISION TECHNOLOGY AND CRAFTSMANSHIP TO SATISFY THE MOST ADVANCED AMATEUR AND PROFESSIONAL ASTRONOMER ALIKE. IT FEATURES MATCHLESS (HAND CRAFTED) OPTICAL AND MECHANICAL COMPONENTS THROUGHOUT, RESULTING IN UNPARALLELED PERFORMANCE.

MANUFACTURERS OF CASSEGRAIN AND NEWTONIAN REFLECTING TELESCOPES, ASKO INSTRUMENTS ARE AVAILABLE IN A VARIETY OF MODELS RANGING IN APERTURE FROM 8.27″ to 23.6″ AND ARE PRICED FROM $7,000.00.

***ACS 450 17.7″ CASSEGRAIN ALSO AVAILABLE IN 19.7″ AND 23.6″ APERTURES**

SPECIAL NOTE: *WE CARRY THE WORLD'S LARGEST AND FINEST SELECTION OF EQUATORIAL MOUNTINGS.*

ASKO
MEADE
UNITRON
PENTAX
GOTO
FUJINON
NIKON
KOWA
UNIVERSITY OPTICS
CELESTRON
OBSERVA-DOME
NOCTRON
MIZAR
BRANDON
ZEISS
QUESTAR
CARTON
YAMAMOTO
M.K.L.
M.K.C.O.
N.K.M.
U.T.S.C.
DOBBINS INSTRUMENT CO.
THE ASTRONOMY SHOPPE

FOR COMPLETE INFORMATION ON OUR ENTIRE LINE OF TELESCOPES AND BINOCULARS, PLEASE SEND $3.00 USA, $6.00 FOREIGN. ALSO SPECIALIZING IN FOREIGN ORDERS.

*EXCLUSIVE INTERNATIONAL DISTRIBUTOR.

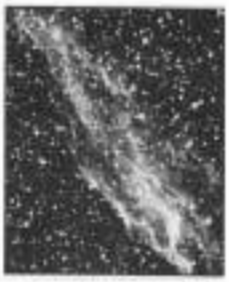
PHONE 7 DAYS A WEEK

R.V.R. OPTICAL (914) 337-4085
P.O. BOX 62 — EASTCHESTER, N.Y. 10709 U.S.A.

DEEP SKY 5

The magazine for deep-sky observers and astrophotographers

Winter 1983
Volume 1, Number 5



Cover: Supernova remnant NGC 6992-5, the Veil Nebula, photographed by Paul Roques; 10-inch f/10 SCT, hypered TP 2415, 90 minute exposure.

p. 6

p. 22

p. 36

Founder and Editor
David J. Eicher
Managing Editor
Katherine Bond
Art Director
Thomas L. Hunt
Associate Editor
Robert Burnham
Contributing Editors
Richard Berry
Glenn F. Chaple, Jr.
Alan Goldstein
Phil Harrington
David Healy
David H. Levy
James E. Meketa
Francis Reddy
Brian Skiff
Harold R. Suiter
Production Assistants
Jane B. Lucius
Mary MacAdam

President, AstroMedia Corp.
Robert A. Maas
Advertising Coordinator
Dana-Lynne Terry
Circulation Director
Kristie Fischer
Circulation Manager
Rosemary L. Pickart

6 Night of the Hunter

by Phil Harrington

Although best known for the most observed nebula in the sky — M42 — Orion is a fine hunting ground for an assemblage of a few open clusters, planetary nebulae, and double and variable stars. But its secret demands patient observing — the constellation is enshrouded in faint emission and reflection nebulae, and that's where the challenge begins.

16 Making Visual Discoveries of Supernovae

by Gregg D. Thompson and James T. Bryan, Jr.

One of the most exciting prospects for galaxy observers is the chance of aiming toward a favorite galaxy, focusing with a low power eyepiece, and eyeing a bright out of place "guest star" on the galaxy's fringes. This article tells you how to increase your chances of spotting one, and provides detailed finder charts for two bright galaxies.

22 Piggybacking Your Camera for Astrophotography

by David Healy

To obtain excellent wide field photos of deep-sky objects, you need not own elaborate and expensive astrophotographic equipment. All you need have is a little practice in the "basics" of astrophotography, a 35mm SLR camera and tracking device, and a wide angle or telephoto lens.

4 Letters to DSM
The observers speak

5 Inside View
In praise of supernova watching

28 Double Stars
Winter's 25 best

29 Variable Stars
The American Association of Variable Star Observers

30 DSM Reviews
Paul Hodge's Atlas of the Andromeda Galaxy

32 DSM Reports
Stellafane and the art of deep-sky observing

36 Scanning the Literature
Stars in galaxy NGC 147
Polar ring galaxies: what are they?
M33 becomes more distant
Photometry of globulars M22 and M92

DEEP SKY magazine is published quarterly by AstroMedia Corp., 625 East St. Paul Ave., Milwaukee, WI 53202. Copyright © 1983 by AstroMedia Corp., all rights reserved. Material in this publication may not be reproduced in any form without written permission. Second class postage paid at Milwaukee, WI. POSTMASTER: Send address changes to DEEP SKY, P.O. Box 92788, Milwaukee, WI 53202. Direct all inquiries, complaints, editorial submissions, and other correspondence to the above address, telephone (414) 276-2689. The opinions expressed in this magazine are not necessarily those of the publisher or editors. AstroMedia Corp. cannot be responsible for unsolicited materials. Names and addresses of authors may be printed unless specifically requested otherwise. Questions about subscriptions: **(414) 276-8547**, weekdays 8am.-4pm. Subscription price (U.S.): 1 year $10, 2 years $18.50, single issue $3; (elsewhere): 1 year $14, 2 years $26.50, single issue $4. Clubs and dealers: inquire about bulk rates. Staff: Mary Algozin, Jacque Berger, Tony Cunning, Susan Poole, Debbie Weinstein, and Dennis K. Wilk. Film production and printing: Eagles Printing, Eau Claire, WI.

Astronomy magazine © 2008 Kalmbach Publishing Co. This material may not be reproduced in any form without permission from the publisher. **www.Astronomy.com**

Letters to DSM

A Colorful Controversy

Dear Dave / In his letter published in the October 1983 issue of ASTRONOMY, Philip C. Steffey seems to imply that colors in deep-sky objects should be visible only in very large telescopes, and then just barely. Fortunately, many amateur observers are unaware of the limitations of their color vision, as a visit to any well attended star party will demonstrate. At least one third of all observers — including passers by with no astronomical knowledge — see M42 as *vivid* green in a good 6-inch refractor. M57 and the Saturn Nebula are also distinctly green with this aperture, although less bright than M42. With a 12-inch reflector, many people see M43 and the outer fringes of M42 as a very deep rose, and several have commented that the Saturn Nebula is so green it looks like "Day Glo" paint.

I would comment to Mr. Steffey that the threshold of color vision varies enormously from person to person, and with observing conditions. For example, to some persons Antares, Betelgeuse and Mars all appear yellowish or white, while others can see colors out of doors rather distinctly in full moonlight. In my experience, children often seem to have better color vision than adults, perhaps because they don't realize they are exceeding their scientifically established limits of color vision.

If the thresholds quoted by Mr. Steffey represent the currently accepted standards for assessing color vision, then a great deal more research needs to be done. I would be interested to receive reports from amateur astronomers concerning their ability or inability to see colors in deep-sky objects.

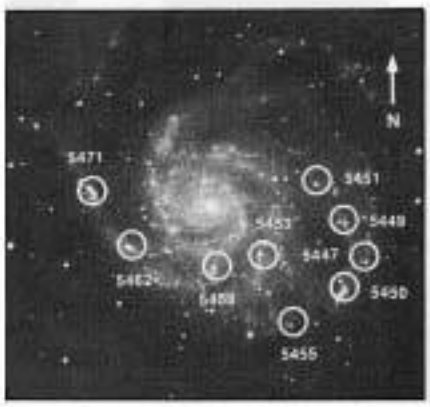
James Meketa
1029 Beacon Street
Newton Centre, MA 02159

Best of the NGC

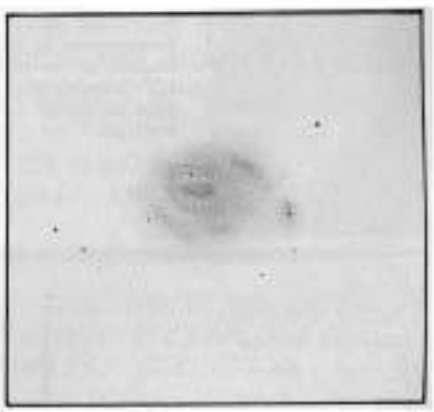
Dear Dave / I would like to correspond and share observations with other amateurs who subscribe to your magazine. I'm currently working on a project of observing all of the NGC objects, and have an extensive catalogue already using telescopes from 90mm to 12.5-inches' aperture. Anyone in the southern hemisphere is especially welcome, too. My aim is to compile a book of aid to amateurs in observing the best of the *NGC*. If anyone is interested, please write me and include a sample of your work.

I've included a sketch of M101 made with my 12.5-inch f/4 reflector at 75x. At this magnification I pick up several "knots" of material in the galaxy's arms: do you know what these might be? The Webb Society's *Deep Sky Observer's Handbook* only mentions "pairs of knots" or "faint detail" but that is all. I hope you'll identify them so that other amateurs will know what detail they're looking at in this low surface brightness galaxy. You'll surely want to know when you get your 18-inch telescope going. I'm looking forward to coming issues of DSM!

K.A. Brownlee



Nebulae in M101 (by NGC#)



Sketch by Jeff Corder

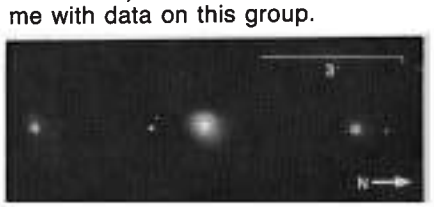
Jeffrey Corder
Box 1082
Asheville, NC 28802

A Curious Galaxy Group Near M13

In August 1983, after admiring M13 with my 13.1-inch Odyssey I, I went looking for a faint group of galaxies which I'd heard was located just 50′ west-southwest of the Great Cluster. After some careful searching, I spotted five galaxies in this locale. In one field, a power of 166x yielded a string of three galaxies; slightly further west and northwest lay two more. A check in the *RNGC* revealed four objects at these positions: NGC 6194, NGC 6196, NGC 6197 and NGC 6199. Unfortunately, the relative positions of the RNGC coordinates did not match up with a sketch I made of the galaxies. Here is what I found: The brightest object in this 8′ string was the central galaxy and I saw it as a small patch with a bright nucleus. Located 5′ south-southeast was a very faint object visible only with averted vision. Similar in brightness was a galaxy located 3′ north-northwest of the central object. Two faint stars bracketed the trio. Moving an eyepiece field to the west,I came across a very small galaxy 16′ west-northwest of the group. This was the second brightest in the region and held steady with direct vision. Finally, I found a small, faint, elongated spot 13′ north-northeast.

Because of my confusion, I sent a letter to Brian Skiff asking for help in sorting out the situation. He quickly responded and identified the brightest in the trio as NGC 6197 (=IC 4616) and its companions as NGC 6096 (=IC 4615) and IC 4614. The galaxy 16′ west-northwest of the group was NGC 6194 and its neighbor 13′ north-northeast was MCG 06-36-55 (from Vorontsov-Velyaminov's *Morphological Catalogue of Galaxies*). In addition, Brian provided me with data on this group.

Gottlieb



(l to r): NGC 6197, NGC 6196, IC 4614

To further pin down the identities, I checked with Dr. Harold Corwin of the University of Texas at Austin. He replied that in compiling the *Second Reference Catalogue* (*RC2*) with the de Vaucouleurs', he encountered an imprecision in the original NGC and IC coordinates; but he verified Skiff's identifications. He added that both NGC 6196 and 6197 were displaced from their real positions by the same amount. When this correction is applied to NGC 6199, a 14th magnitude star shows up at the new position. Certainly no galaxy exists at the original or offset position, so NGC 6199 is nonexistent. The *IC* also lists IC 4613 in this area, but no object is visible at its position. However, 6′ south there is another faint unidentified galaxy.

This group is rather easy to locate due to its proximity to M13, so I hope that other amateurs will enjoy observing it. I've included a sketch of the region for identification purposes.

Steve Gottlieb
155 San Carlos
El Cerrito, CA 94530

K.A. Brownlee

Stephan's Quintet photographed with a 16-inch reflector.

Clusters of Galaxies

Dear Sir / I'm an ASTRONOMY and DEEP SKY reader since the beginning of this year. It's really a pleasure to read these two American reviews and especially the latter because I'm in love with the deep-sky. I'd be happy if you could publish a photograph of "Stephan's Quintet" and other clusters of galaxies we can see visually in the Dobson of a friend of mine (Christian Hanon; DEEP SKY 2, p.4). It's a 17.5-inch Coulter mirror and gives crisp views of faint deep-sky objects. Thanks for all you'll do in the future and keep on your articles and reviews.

Jean-Baptiste Cretaux
4, rue Grande (Pharmacie)
St. Pierre du Vauvray
27430 FRANCE

Dear Mr. Cretaux / We're gearing up to do a feature story on observing clusters of galaxies sometime in the near future, but for now here's Stephan's Quintet, prematurely back by popular demand. — DE

Paradise Found?

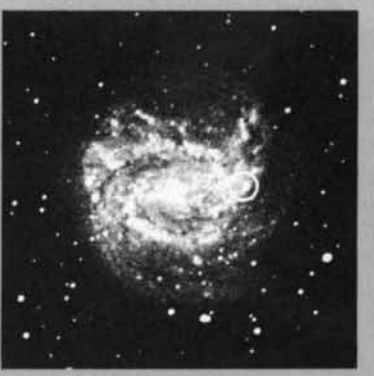
Dear Mr. Eicher / After reading the Fall issue of DEEP SKY I must say I'm very pleased with the way it looks. I think you and your people have done a great job. I'd like to tell you about something you may not know of, however.

How many of your readers would like to have a dark sky location on a mountaintop in Arizona with a beautifully clear sky, electricity, shelter, sleeping quarters, rest rooms, and security? Too good to be true? Well, we have it and here's the best part: we intend on making it available to any amateur who wishes to use it, creating a "National Amateur Observatory" of sorts. We hope that eventually astronomers from all over the country will use the facility.

The site lies on McCloud Mountain, about three miles northwest of Hillside, Arizona, at an elevation of 4960 feet. It is within an hour of Prescott and two hours of Phoenix. If anyone is interested in using this site, please have them get in touch with me.

George de Lange
13015 North 24th Street
Phoenix, AZ 85032

In Praise of Supernova Watching



Item: On April 6, 1983, astronomers at the Tokyo Astronomical Observatory reported the discovery of a 13th magnitude "exploding star" near the nucleus of spiral galaxy NGC 4753 in Virgo. Before it was officially confirmed, Australian amateurs Robert Evans (who had already discovered one supernova) and Gregg Thompson independently found the intruder.

Item: May 11 and 12: Russian astronomers discover a 15th magnitude supernova in Sc-type spiral NGC 6217 in Ursa Minor and a similarly bright object in Sc galaxy NGC 4051 in Ursa Major. The supernova in NGC 4051 is independently picked up by Americans John Kielkopf, R. Brashaer, Alan Goldstein, and R. Gabart at the University of Louisville.

Item: June 6: J. Maza, working at the University of Chile, discovers a 17th magnitude exploding star in the Sa-type spiral NGC 4699 in Virgo. Within four days the supernova dramatically brightens to 14th magnitude. Within three days Maza identifies another supernova, this time in faint galaxy ESO 406-G27 in Grus.

Item: July 2: astronomer Paul Wild, working at the Astronomisches Institut, Berne, Switzerland, finds a magnitude 14.5 out of place "star" in the Sa-type galaxy NGC 4220 in Canes Venatici.

Item: July 3: amateur astronomer Robert Evans of New South Wales, Australia, discovers a supernova in the Sc-type galaxy M83 in Hydra. This is his unprecedented third visual discovery of an extragalactic supernova. The star shines at 13th magnitude and within a week brightens to 10th.

Item: July 11: astronomers at the Observatorio Astrofisico Brasileiro in Brazil discover a 13th magnitude supernova in the Sb-type spiral NGC 5746 in Virgo.

Item: At the beginning of September, Maza finds a 15th magnitude supernova in the Sc-type spiral NGC 7418 in Grus.

Item: Wild reports his discovery, on October 1, of a 14th magnitude supernova in the faint galaxy IC 1731 in Triangulum. This supernova is independently found by a Russian astronomer.

Item: On October 6, Evans, breaking his own record, visually discovers a magnitude 14.5 exploding star in the spiral NGC 1448 in Horologium. It appears to be a Type II supernova.

The practice of hunting for supernovae in other galaxies is a demanding one. It demands skillful use of a telescope. It demands knowledge of what field stars surround innumerable faint fuzzy galaxies. And most of all it demands patience and perseverance. It seems an incredibly rare event to catch, yet the record shows at least 11 bright supernovae — within the reach of amateur instruments — becoming visible in the last six months, four of them discovered in part by nonprofessionals.

A group of amateurs in Australia is currently working on a project of producing supernova finder charts, something that will make supernova searching much easier in the future. Gregg Thompson, who independently found the supernova in NGC 4753, is the leader of this group and, with Jim Bryan of Texas, has written an article on this project, beginning on page 16. If you're as excited by the charts as I am, you can join me in eagerly awaiting their publication!

Clear skies and warm regards,

Dave Eicher
Editor

Background: Orion rises over Lick Observatory on Mt. Hamilton, California. Photo by James Baumgardt. *Inset:* This deep exposure of the constellation shows Barnard's Loop, M42, the Horsehead nebulosity around Lambda (λ) Orionis, and thousands of Milky Way stars. Photo by Jack Marling; 50mm f/1.8 lens, hypered TP 2415, Hα pass filter, 60-minute exposure. A satellite crossed the field during the shot.

Night of the Hunter

by Phil Harrington

M42 photo by Al Lilge; 12.5-inch f/8 RCT, 45 min. on 098 emulsion.

Winter is a season of rapidly changing weather conditions. With the passage of an arctic cold front, a cloudy day may suddenly give way to a spectacularly clear and transparent — if somewhat unsettled — night. Such evenings are among the best all year for deep-sky exploring. Who cares about mediocre seeing when the night sky is ablaze with dazzling suns suspended in an ocean of black ink? Untold thousands of faint stars, many of which are usually invisible, beckon you and your telescope out from the warm confines of your home. Dominating the vista, high above the southern horizon, is one of the brigthest and best known constellations in the heavens — Orion, the mighty Hunter. Within its borders lie several of the most beautiful and elusive interstellar treasures.

Few of us, beginners or old hands, would dispute that **M42**, the Great Nebula in Orion, is the grandest view awaiting the telescope owner. To the unaided eye, the nebula shows up as a small hazy patch surrounding Theta (θ) Orionis, the middle star in Orion's sword. In binoculars or a telescope, however, the area expands to a captivatingly unique telescopic sight. My 8-inch f/7 reflector reveals a tremendous greenish nebulosity with several stars embedded in it. At 54x, the nebula more than fills the field. On its northeast corner is a dark protrusion, dubbed the "fish's mouth" by mid-19th century observer Admiral William Smyth. Near its tip lie the four stars of the "Trapezium," easily resolved in nearly all telescopes. What a view!

Telescopic descriptions and sketches, though they communicate a feeling of what's visible through the eyepiece, fall short with M42. Unfortunately they cannot possibly capture the sublety and wide range of brightness in the nebulous gas. Even the finest photographs do not convey the same thrill as viewing M42 visually. And you can hardly miss: the Great Nebula appears impressive under almost any magnification, each offering a different perspective. Black skies and low powers work best to see faint outlying wisps of nebulosity frequently overlooked by casual observers. Wait for a dark, moonless night, and use averted vision. Medium powers are best for revealing the complex mottled structure and its varying colors and contrasts. As you move in to view the area in and around the Trapezium, choose the highest magnifications the night's seeing conditions allow.

The Trapezium (also known as Theta^1 [θ^1] Orionis) is a quadruple star, with members of magnitudes 6.8, 7.9, 5.4, and 6.3. Traditionally, these stars are referred to as A, B, C, and D, in order of right ascension. In 1975, astronomers

M42

8-inch f/6 Newtonian 55x

Sketch by
Phil Harrington

discovered that A, the westernmost star, is an eclipsing binary, fading a full magnitude for twenty hours every 65.4 days. B, officially known as BM Orionis, is also an eclipsing binary, with a 6.5 day period. There are three other stars in the group: stars E, F, and G. In 1826 German astronomer F.G.W. Struve discovered star E, which appears as an 11th magnitude object about 4″ north of A. F is also an 11th magnitude object, about 4″ southeast of C. Lastly, G shines at magnitude 16, and therefore is visible only in instruments of 14-inches' aperture or more.

The Orion Nebula shines by fluorescence; it is a region of ionized gas excited into luminescence by the strong ultraviolet radiation from hot stars of the Trapezium. Principally composed of hydrogen, M42 also contains helium and trace levels of carbon, oxygen, nitrogen, sulphur, neon, chlorine, argon, and fluorine. The greenish color you see is chiefly due to two emission lines of doubly ionized oxygen. Other colors are also present — pink, purple, red, blue — but are invisible to human eyes. Good color photographs of M42 show some of this coloration.

M42 is probably about 1,600 light-years distant, and measures 40 light-years across, thus it is more than 25,000 times the size of our solar system. But compared to clouds in some galaxies we observe nearby (see "Gas Clouds in Galaxies" in DEEP SKY 4), M42 is a mere midget. It is one of the youngest nebulae we can observe, probably no more than 30,000 years old. The quantity of gas within it is staggering — enough to produce 10,000 stars like our Sun — yet the density is less than a millionth that of a good laboratory vacuum!

Besides those in the Trapezium, a number of other variable stars lie within the Orion Nebula. Perhaps the most interesting is **T Orionis**, some 5′ south of the Trapezium. This is a T Tauri type star, a very young star still found amidst nebulosity. It varies irregularly between magnitudes 9.5 and 12.6. What makes the star so interesting is that it may maintain a constant brightness for several weeks or months, then suddenly fluctuate violently at a rapid rate. Since you never know what it'll show on any given night, astronomers must constantly monitor it — and so can you.

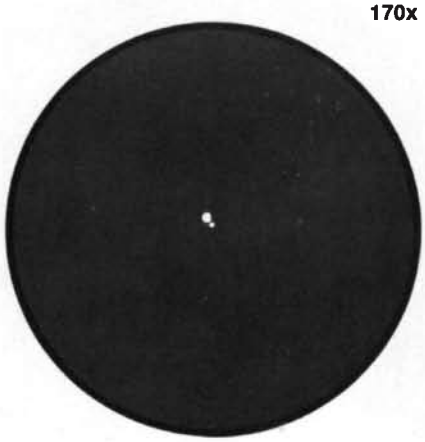
M43 appears as a detached portion of the Great Nebula, about 7′ north of its more impressive neighbor. Frequently observers don't distinguish this 15′ x 20′ patch as a separate object. In fact, Nicholas Peiresc discovered M42 in 1611, but M43 wasn't recognized until 1731. Apparently, it is a detached portion of the same gas cloud — "cut off" by a dark dust

Deep Sky Objects in Orion

Type	Object	R.A. (1950)	Dec.	Mag.	Size/Sep./Per.
■	J320	05h 02.7m	+10° 39′	13	10″
□ER	1788	05 04.5	−03 24	—	8′x5′
★²	Beta (β)	05 12.1	−08 15	0, 7, 14	9,4″
★²	Delta (δ)	05 29.4	−00 20	2, 6.5, 14	53″,33″
□R	IC 423	05 30.9	−00 40	—	4′x2′
□R	IC 424	05 31.5	−00 25	—	—
★⁴	Theta¹ (θ¹)	05 32.8	−05 25	5, 6, 7, 8	13″,13″,17″
□E	M42 (1976)	05 32.9	−05 25	5	65′
□ER	1973-75-77	05 33.0	−04 52	—	40′x25′
★²	Iota (ι)	05 33.0	−05 56	3, 7, 11	11″,50″
□E	1980	05 33.0	−05 56	—	14′
⊙	1981	05 33.0	−04 24	7	20′
□E	M43 (1982)	05 33.1	−05 18	—	5′
IV	T	05 33.4	−05 30	9.4-12.6	Irr.
□ER	1990	05 33.7	−01 14	—	50′
□ER	1999	05 34.1	−06 45	—	16′x12′
□R	IC 426	05 34.3	−00 16	—	5′
□R	IC 430	05 36.2	−07 06	—	10′
★²	Sigma (σ)	05 36.2	−02 38	4,6,7.5,10,6.5	13″,11″,42″
□R	IC 431	05 38.0	−01 25	—	5′x3′
□R	IC 432	05 38.5	−01 31	—	4′x5′
□E	IC 434	05h 38.6m	−02° 26′	—	60′
□D	B33	05 38.7	−02 32	—	3′
□ER	2023	05 39.2	−02 15	—	10′
■	2022	05 39.3	+09 03	12	25′
□E	2024	05 39.4	−01 52	—	20′
□R	IC 435	05 40.5	−02 20	—	3′
IV	FU	05 42.6	+09 03	9.7–16	Irr.
□D	B35	05 42.6	+09 03	—	30′
□R	2064	05 43.1	−00 01	—	4′x2′
□R	2067	05 43.3	+00 01	—	6′x3′
□R	M78 (2068)	05 44.2	+00 02	8	6′x8′
□R	2071	05 44.6	+00 17	—	4′x3′
⊙	2112	05 52.5	+00 22	9	9′
LPV	U	05 52.9	+20 10	5.4–12.5	373d
★²	Mu (μ)	05 59.6	+09 39	4.5,6.5	0.2″
⊙	2141	06 00.3	+10 26	11	8′
⊙	2169	06 05.7	+13 58	7	4′
⊙□E	2174/75	06 06.7	+20 51	—	25′
⊙	2186	06 09.4	+05 27	9	5′
⊙	2194	06 11.0	+12 50	9	8′

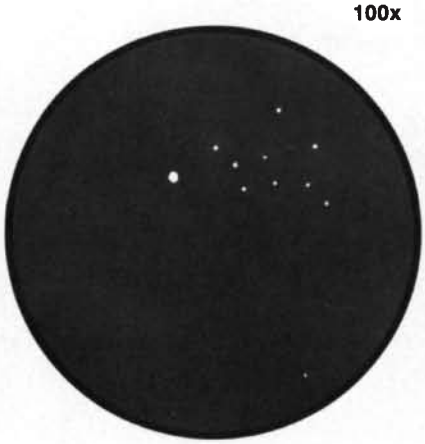
LPV long period variable
IV irregular variable
★² double star
★⁴ quadruple star
⊙ open cluster
■ planetary nebula
□D dark nebula
□E emission nebula
□R reflection nebula
□ER complex nebular region

Rigel — 3-inch f/10 reflector, 170x



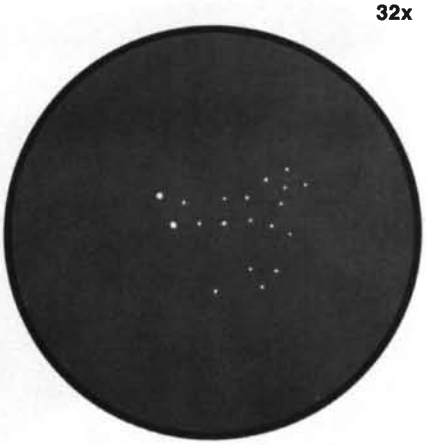
Sketch by Glenn F. Chaple, Jr.

NGC 2112 — 6-inch f/8 reflector, 100x



Sketch by Chesley Runyon, Jr.

NGC 1981 — 6-inch f/8 reflector, 32x



Sketch by Stephen Nekolek

cloud — but illuminated by its own 8th magnitude star. Indeed very long exposure photographs show that not only the immediate area of Orion's sword, but nearly the entire constellation, is enveloped in nebulosity.

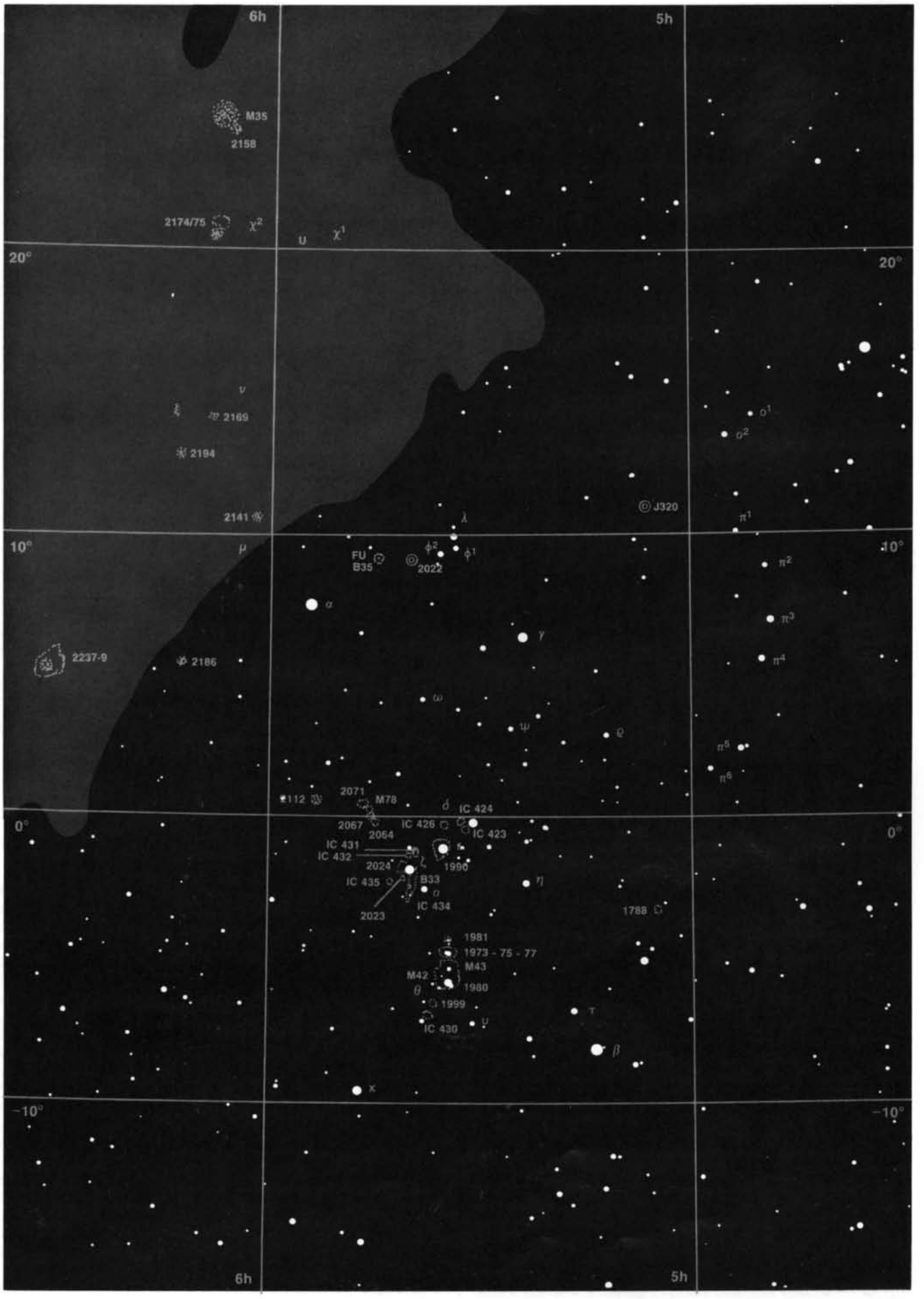
One such patch of nebulosity surrounds **Iota (ι) Orionis** — the southernmost star in Orion's sword — and is catalogued as **NGC 1980**. Using my 8-inch, I have to use averted vision to detect even the slightest hint of this cloud. A 12.5-inch Newtonian I've used reveals little more. Clean, large-aperture optics and an exceptional evening are required to minimize the overpowering glare of the star. Iota is a deep-sky splendor in its own right. Even in small telescopes, Iota blossoms into an easy triple. The primary is a magnitude 2.8 type O9 star; the companions are separated by 10″ and 50″, with apparent magnitudes of 7 and 11 respectively. Keen-eyed observers may detect some star colors with this triple — the primary appears whitish, the companions bluish and pale red. This multiple system is about 2,000 light-years distant and, curiously, the primary star is also a spectroscopic binary, making Iota a quadruple system! The easy double Σ747 (mags. 5.5, 6.5; sep. 36.0″; p.a. 223°) lies in the same low-power field, about 8′ southwest.

the third volume of the Webb Society's *Deep Sky Observer's Handbook*, the authors state that NGC 1981 is visible in 10x50 binoculars as a "large, scattered, resolveable object." If this is true, it's interesting to speculate what the smallest instrument might be that allows positive identification of NGC 1981.

About a degree south of M42 is **NGC 1999**. This object measures 16′ x 12′, but is so faint that you'll find it very

On the other side of the Great Nebula, half a degree north, is a large (40′ x 25′) emission nebula complex made up of **NGC 1973**, **NGC 1975**, and **NGC 1977**. These numbers apply to portions of the same cloud which are excited to glow around three bright stars. In the 8-inch, NGC 1973 and NGC 1975 appear as small, faint patches, oval in shape. Both required averted vision. NGC 1977 is even more difficult, as it surrounds the 4th magnitude star 42 Orionis. You'll need clear, dark skies to successfully view these very difficult targets.

Switch to a low power, wide-field ocular for viewing our next object. **NGC 1981** is a coarse scattered open cluster containing 45 stars which lies just north of NGC 1977. Using the 8-inch last winter under crystal clear skies, I saw fifteen stars of magnitude 8 to 11 scattered across a 45′ field. In


6h
5h
M35
2158
2174/75
χ²
υ
χ¹
20°
20°
ν
2169
2194
2141
λ
J320
o¹
o²
π¹
10°
μ
10°
FU
B35
2022
φ²
φ¹
α
γ
π²
π³
π⁴
2237-9
2186
ω
ψ
ϱ
π⁵
π⁶
112
2071
M78
δ
IC 424
0°
2067
IC 426
IC 423
2064
IC 431
IC 432
50
ζ
2024
1990
IC 435
B33
η
σ
IC 434
2023
1788
1981
1973 - 75 - 77
M43
M42
θ
1980
1999
IC 430
υ
τ
β
χ
0°
−10°
−10°
6h
5h

Above: **B33, the Horsehead Nebula, is one of the most difficult objects to observe in the sky. Photo by David Healy, using a 14-inch SCT at f/6.5, hypersensitized TP 2415 emulsion, and an 80-minute exposure.** ***Above right:*** **NGC 2141 is a fairly rich group of faint stars 8′ across. Photo by Martin C. Germano; 8-inch f/10 SCT 103a-F film, 75-minute exposure.** ***Far right:*** **The brightest planetary in Orion, NGC 2022, appears stellar at all but high powers. Germano photograph; 8-inch f/10 SCT, 103a-F emulsion, 19-minute exposure.** ***Right:*** **M78 is a bright reflection nebula north of the Hunter's belt. Photo by Lee C. Coombs, using a 10-inch f/5 Newtonian, 103a-E emulsion, and a 15-minute exposure.** ***Left:*** **A difficult reflection object, NGC 1973/75/77 lies just north of M42. Germano photograph; 8-inch f/10 SCT, 103a-F emulsion, 35-minute exposure.**

difficult to see. Under good conditions a moderate-sized telescope shows a small nebulous patch surrounding the 10th magnitude T Tauri variable V380 Orionis. A dark "absorption bay" exists within the nebula, but I couldn't see anything of it with either the 8-inch or 12.5-inch telescope. An even more difficult nebulosity is **IC 430**, a 10′ long streamer of gas about 8′ northwest of the star 49 Orionis. Perhaps observers with large, fast scopes can spot this one, but for now I've added it to my "does this thing really exist?" list.

Among the mighty Hunter's interesting double and multiple stars is **Rigel** (Beta [β] Orionis), the brightest star in the constellation and seventh brightest in the sky. Rigel is a magnitude 0.3 type B8 supergiant. It has a luminosity some 57,000 times that of the Sun, which makes it one of the most luminous stars in the Galaxy. The faint bluish companion — magnitude 6.7 — lies only 9″ away at p.a. 202°, and so is fairly difficult to view. A 4-inch to 8-inch scope at high power will do the trick on nights of steady seeing. These two stars, incidentally, have shown virtually no change due to orbital motion since the discovery of the companion by F.G.W. Struve in 1831. **Mintaka** (Delta [δ] Orionis), the westernmost belt star, is an easily resolvable binary star. A look at Mintaka through large binoculars or a small telescope displays a 2nd magnitude primary star and a magnitude 6.7 companion about 53″ due north. Given an estimated distance of about 1500 light-years from Earth, the distance between the two stars is thought to be nearly half a light-year. Observers with large telescopes may be able to detect a third star in this system; look for a 14th magnitude speck of light about 33″ from the primary in p.a. 227°. Mintaka is also notable for another reason: at Potsdam Observatory in 1904, astronomers discovered stationary lines of calcium superimposed on its spectrum, which proved the existence of interstellar matter.

Rivaling Theta[1] Orionis as the finest multiple star in Orion is **Sigma** (σ) **Orionis**, just south of Alnitak. A low or medium power eyepiece shows four of the five stars in this system, whose pearly-white primary shines at 4th magnitude. A 10th magnitude companion is situated about 11″ away at p.a. 236°. A 7th magnitude star lies 13″ distant at p.a. 84°, while the most removed member is a 6th magnitude object, some 42″ away at p.a. 61°. Upon closer inspection with high power, the primary star is itself double — the elusive 6th magnitude companion a mere 0.25″ distant at p.a. 199°. Can you spot all five stars in this group?

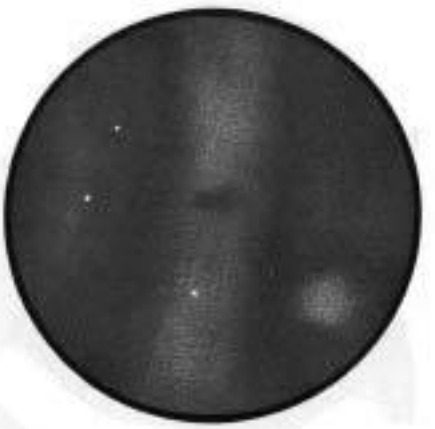
Nebular patches abound in the belt region. Surrounding

M78 & NGC 2071

Sketch by Phil Harrington

8-inch f/7 Newtonian 84x

B33



Sketch by Chuck Coates

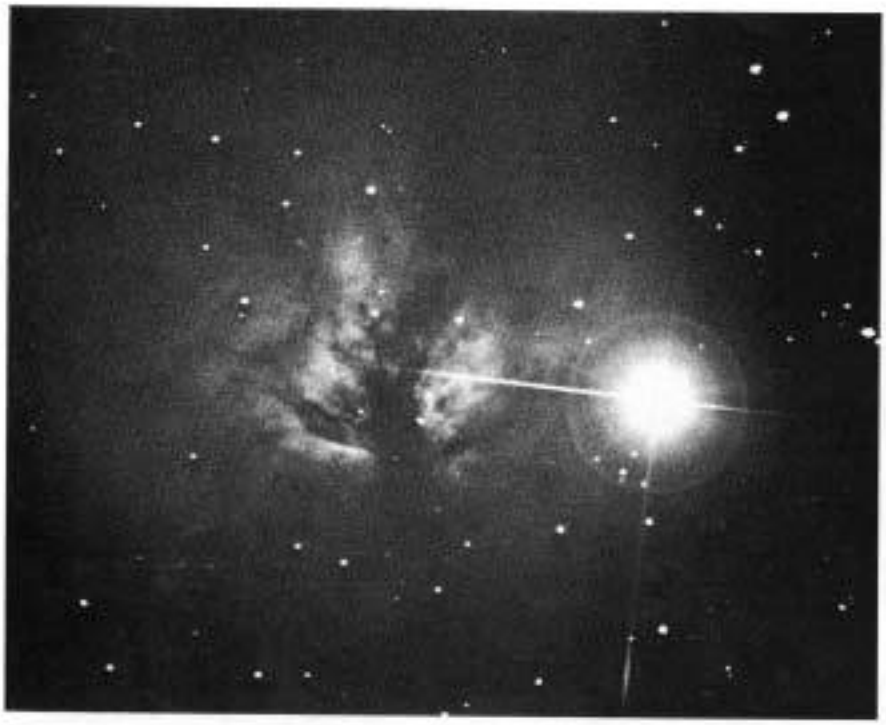
12.5-inch f/5 Newtonian 80x

Alnilam (Epsilon [ε] Orionis), the belt's center star, is a large — 50′ — complex of emission and reflection nebulosity, **NGC 1990**. This is a difficult target for backyard observers, as the light from second magnitude Alnilam tends to overwhelm the nebulosity. A large aperture, wide field scope may pick it up, especially if you move the bright star slightly out of the field — perhaps with an occulting disk or bar at the focal plane of your eyepiece. The area around **Alnitak** (Zeta [ζ] Orionis) — the easternmost belt star — is teeming with interstellar clouds, the brightest of which is **NGC 2024**. My 8-inch scope displayed this patch as a bright, oval glow with little surface detail; the 12.5-incher showed little further detail. Many observers report seeing a dark absorption band bisecting this object: even 6-inch instruments show this feature on dark nights. **IC 434**, a thin strip of emission nebulosity, extends over a degree south of Alnitak. Due to its great extent and low surface brightness, this is a difficult find for backyard observers. The brightest portion is visible near Zeta, its exciting star; it quickly fades away as one scans southward.

Near the middle of IC 434 is the tiny dark nebula **Barnard 33**, better known as the Horsehead Nebula. This is cloud of tiny, cold dust granules about a light-year in diameter, projected onto the face of IC 434. The late variable star observer Leslie C. Peltier once glimpsed the Horsehead with a 6-inch refractor — and veteran deep-sky observer Walter Scott Houston detected it using a 5-inch Apogee moonwatch telescope — but this small dark patch is one of the most difficult objects in the entire sky. Were it placed in an anonymous patch of sky, it would be a most difficult object: however, with the 2nd magnitude star Alnitak only half a degree away, the task of spotting the nebula becomes much more complicated. Success comes with knowing exactly where the little dark patch is located, and using a wide field ocular and a trained eye. If you do spot the Horsehead, you're among a very select group of observers. Good luck!

There are no fewer than seven other bright nebulae in the vicinity of Orion's belt. They include **NGC 2023**, **IC 423**, **IC 424**, **IC 426**, **IC 431**, **IC 432**, and **IC 435**. All are faint, elusive objects that require a large aperture.

About a degree west of 60 Orionis is the fine open cluster **NGC 2112**. My 8-inch scope displayed a moderately rich open cluster with many stars of 10th magnitude and fainter spread over 2′ x 4′ area. The overall magnitude of this group is about 8.5, allowing for detection (theoretically, at least) in even a 2-incher. A 4-inch scope shows a bright group of nearly a dozen stars, one being brighter than the rest.



Left: **The unusual emission nebula NGC 2024 lies adjacent to the bright star Zeta (ζ) Orionis and is crosscut by a dark absorption band. Photo by David Healy; 8-inch SCT at f/5, 103a-E film, 30-minute exposure.** ***Above:*** **Visually a notoriously hard object, emission nebula NGC 2174 shows in this Rick Dilsizian photo as a glow surrounding cluster NGC 2175. Rick used an 8-inch f/1.5 Schmidt camera, hypered TP 2415 emulsion, and an 8-minute exposure.** ***Facing page:*** **To photograph a large chunk of the winter Milky Way — including Orion — Gordon Solberg photographed it using his 5x50 moonwatch scope backwards. It is a 15-minute exposure on Tri-X.**

NGC 2022 **21-inch f/5 Newtonian 267x**

Sketch by Alan Goldstein

NGC 2169 **4-inch f/15 Maksutov 95x**

Sketch by Rick Hunter

Two degrees farther west along the celestial equator is another clump of bright gaseous nebulosity, highlighted by the reflection object **M78** (NGC 2068). Pierre Mechain discovered this 6′ x 8′ patch of light in 1780; 50 years later Smyth described it as "two stars in a very wispy nebula." This is close to the visual impression gleaned from modern-day telescopes — I saw a small cometary nebula with two tenth magnitude nuclei and a small broad "tail." Just northeast of M78 is **NGC 2071**, visible only as a faint glow at 54x in the 8-incher. Bordering M78 to the southwest are **NGC 2064** and **NGC 2067**. Both were invisible in the 12.5-inch scope under fair conditions. Perhaps better skies would have shown the pair with relative ease.

Variable star observers know that many sights await them in Orion. **U Orionis** is a long period variable just east of 54 Orionis. According to AAVSO predictions, U will attain its magnitude 6.3 maximum in October 1983. Over the coming winter, it will fade gradually until reaching a minimum of about magnitude 12.0 in March. Try estimating the star's brightness every ten days or so, and develop your own light curve. How do your observations compare to the predictions?

While you're in this part of Orion, sweep about 4° east to find **NGC 2174** and **NGC 2175**. NGC 2174 is a rather faint and difficult patch of emission nebulosity, while NGC 2175 is the open cluster associated with it. The 12.5-inch scope showed only a few loosely grouped stars, some showing a hazy appearance. The nebulosity has a low surface brightness, and is generally not too impressive save in very large scopes.

Another interesting variable is **FU Orionis**, about 2° east of Orion's head. This is an unusual star, considered by many to be a slow nova, by others to be a strange nebular variable. Prior to 1937, FU shone at an inconspicuous 16th magnitude. It then rose suddenly to 9.7 over a 90-day period. Some 25 years later it had faded to magnitude 11, and today it continues to decline. Will it flare up again in the future? Stay tuned! Incidentally, FU Orionis is positioned almost directly in front of **Barnard 35**, a little known dark nebula associated with the star.

Nearby is **NGC 2022**, one of two planetary nebulae in Orion within the reach of amateur telescopes. Through the 8-inch, I saw 2022 as a relatively large 12th magnitude orb displaying a bluish hue. High power reveals a slightly oval disk, with a major axis oriented at p.a. 20°-200°. Those with 10-inch or larger instruments may be able to spot the 14th magnitude central star. The second planetary is located in the

constellation's sparse northwest corner. **J320** is a magnitude fainter than 2022, and since it measures only 10″ across, is difficult to find. I've missed this object in my 8-inch Newtonian, though a friend using an 8-inch Schmidt-Cassegrain picked it up. Score one for longer focal length optics. If you own a refractor or other long focus instrument, let DSM know how you do on small objects like these planetaries.

In the southwest region of Orion is a small patch emission and reflection nebulosity dubbed **NGC 1788**. This is often overlooked because of its barren location — 1.5° north of Beta (β) Eridani — but a 6-inch scope shows this object as a faint glow. A 12.5-incher causes it to brighten up and reveal a few stars buried within the gas.

Several more open clusters lie within the constellation. **NGC 2186** is a fairly poor open cluster lying along Orion's border with Monoceros. Look for about two dozen stars of magnitude 11 and fainter gathered in a 10′ field. Just as unimpressive is **NGC 2141**, positioned just north of the double star Mu (μ) Orionis. The 8-inch displayed only half a dozen stars in this group. Xi (ξ) Orionis, in the hunter's raised right arm, is a good point from which to begin your search for **NGC 2169**. This is a small, bright cluster, which consists of only about 15 to 20 stars ranging in magnitude from 8 to 12. Although the cluster is poor, the surrounding Milky Way fields offer some spectacular views.

Near the stellar pair 73 and 74 Orionis is **NGC 2194**. My notes recall a round, compact open cluster with many faint stars. Actually, 2194 contains about one hundred stars, all clumped into an 8′ diameter. In many respects, it reminded me of a poorer M11, but at magnitude 10 it is much fainter. Although greatly overshadowed by so many famous objects in the winter sky, NGC 2194 is among the finest open clusters of the season. Take the time to find it.

There you have it — the best deep-sky objects in what many call the best and most recognizable constellation in the sky. Don't let the cold cause you to miss the Hunter's offerings. There are many types, brightnesses, sizes, and shapes of deep-sky objects in this majestic group of stars, and if you take the trouble to seek out and observe them, you'll get a good representative taste of the winter sky. If you've never picked up the habit, make a point of recording your observations in a notebook of some kind and try your hand at sketching some of the brighter objects. The "Night of the Hunter" will surely be one which you'll remember long into the summer, when Sagittarius comes along to steal away your fancy.

MAKING VISUAL DISCOVERIES OF SUPERNOVAE

by Gregg D. Thompson
and James T. Bryan, Jr.

A supernova is nature's single most energetic stellar event. In one explosive outburst, a star will emit light equaling hundreds of millions of normal stars as it blows off its outermost layers. The by-products of a supernova explosion include massive outpourings of ultraviolet light, X-rays, and gamma rays. In addition, the explosion throws off a wide variety of chemical elements manufactured by the star. The aftermath of a supernova is a small, dense, and rapidly spinning object called a neutron star, and a cloud of hot gaseous debris that expands and eventually dissipates into the interstellar medium. Astronomers calculate that perhaps one supernova occurs every 50 years or so in the average galaxy.

In the years since supernovae (commonly abbreviated SN) were first recognized, astronomers have devoted much time and effort to detecting and analyzing them. Unfortunately, the last SN observed in our Galaxy occurred in 1604 and so astronomers have been forced to observe them in other galaxies. Search programs in Italy, Switzerland, Chile, and the United States have uncovered over 500 such supernovae. However, only a small number of these yield enough scientific information to allow deeper inquiry into how the SN process works.

There is thus a continuing need for the early discovery of bright SN to promote research — and this is where the backyard observer can put his telescope to work. As long ago as 1939 some astronomers envisioned that people with small telescopes could efficiently close gaps in the coverage of established search programs. Since 1974 we have been working to develop a program to help non-professionals search for SN in nearby bright galaxies. The biggest problem, we've found, is a lack of adequate maps of the galaxies to be studied.

There is at least one program — Ben Mayer's PROBLICOM — which searches for supernovae (and ordinary novae) photographically. This, however, requires an equatorial telescope or a well-mounted camera with a reliable, accurate drive and some means of comparing patrol exposures of a galaxy with ordinary exposures of it. Photographic searches lack certain advantages that visual search programs have.

First and foremost, a visual observer can detect a SN brighter than the telescope's limiting magnitude almost immediately, whereas film may not be developed and inspected for many days or more. (In addition, with photos, a second exposure is almost a necessity to rule out film flaws.) Second, far more bright galaxies can be searched visually by an experienced observer than can be photographed, developed, and compared over a similar period of time. Third, a visual program incurs negligible cost in comparison to the expense involved in photographic searches. Related to this is the fact that a greater number of observers can participate in a visual program than in a photographic one which will require extra equipment and expertise. Lastly, the human eye can more readily detect a SN occurring over bright sections of a galaxy than a photographic emulsion.

Without doubt, a visual search program offers major advantages for the discovery of bright SN compared with a photographic program, *provided* suitable reference charts are available.

At first it seems as if photographs would be the ideal chart — a photo is "real" and they're widely available in books. But those who actually try using photographs of galaxies as a reference encounter many problems. Stars that are visually superimposed on bright regions of a galaxy are usually indistinguishable in photographs. Distant galaxies and HII regions can often appear star-like, resulting in incorrect identification. The outer regions of galaxies where SN frequently occur can be cropped out of the photo. Scale and orientation are seldom given and even if they are, vary greatly. The typical photograph is a long exposure that records far more stars than can be seen visually. And lastly, photographic stellar magnitudes do not necessarily correspond to visual ones.

The flaws in using photos as maps drove us to explore alternate approaches for a visual SN search program, and chartmaking soon became a chief objective. Through trial and error, we have devised a technique that produces functional and trustworthy charts. Initially, we attempted to make freehand drawings of galaxies and their field stars as seen in the telescope. Logical though it sounds, this method was fraught with errors in distortions of scale, inaccurate star magnitudes, and the likelihood of failing to map faint stars — not to mention faulty draftsmanship itself. We needed better.

As we had access to the Palomar, ESO, and UK Schmidt Sky Survey plates, we then tried suitably enlarging the plates as a base on which to plot stars visible in the telescope. This also proved impossible as the magnitudes of stars on the tracings were too inaccurate to be sure the right stars were being plotted.

Finally we settled on photographic enlargement prints copied from the Survey plates. Included are all galaxies in

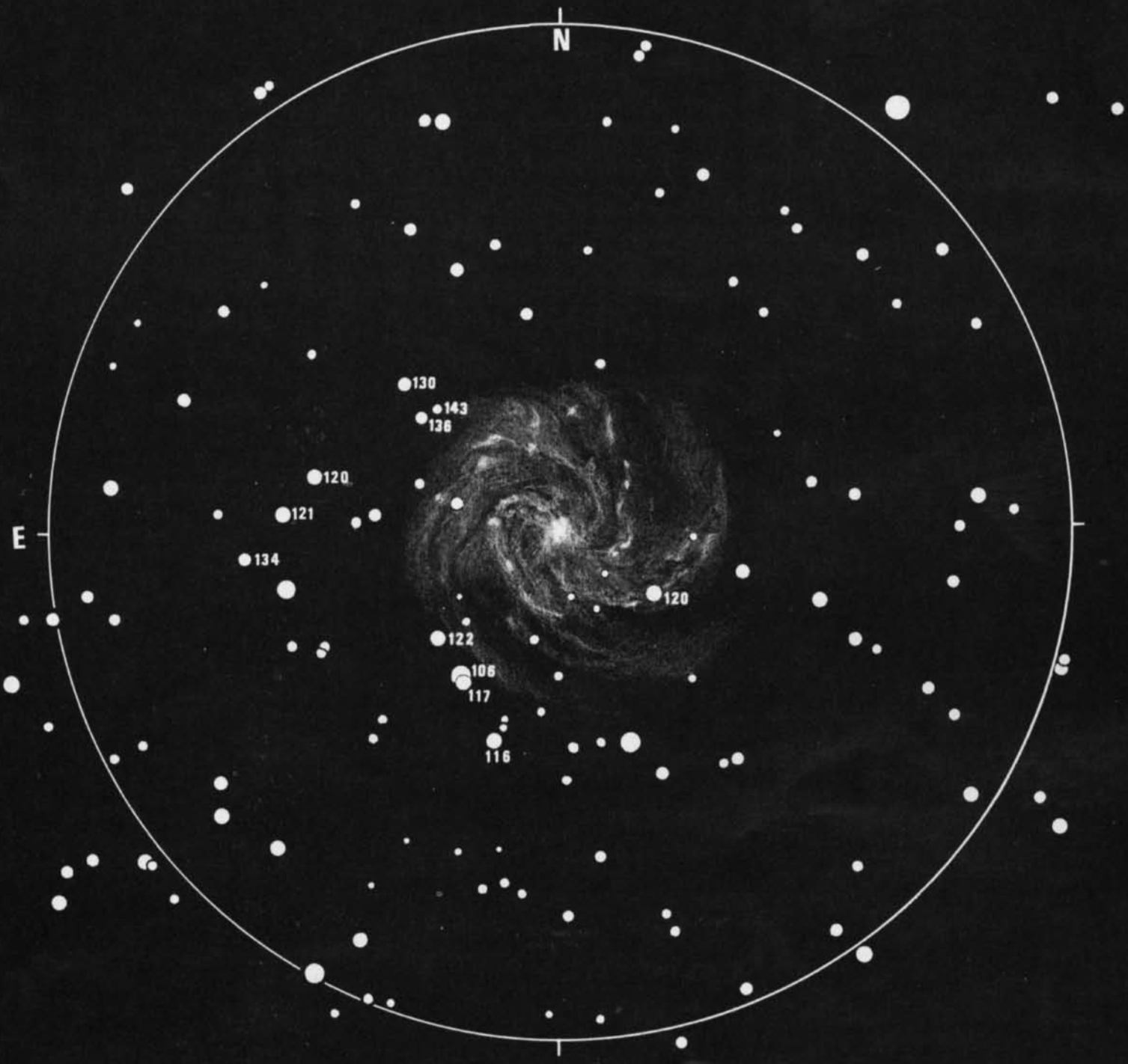
Searching for a supernova in a galaxy is not easy. It takes at least a medium size telescope, much persistance, a measure of luck, and charts that will show the foreground stars in the field of view. The chart at right shows the spiral galaxy NGC 5236, also known as M 83, in Hydra. To judge the brightness of any supernova that may occur, the magnitudes of some field stars are given. To prevent confusion, these have the decimal point omitted; thus, 120 is 12.0 magnitude, 117 is 11.7, and so on.

S.P. Chart No. 14
Scale: 10″ = 1mm.

NGC 5236

Mag. 8.0
Dim. 10.5′ x 9.3′

R.A. (1950) 13 34.3 DEC. −29 37
(2000) 13 37.1 −29 52



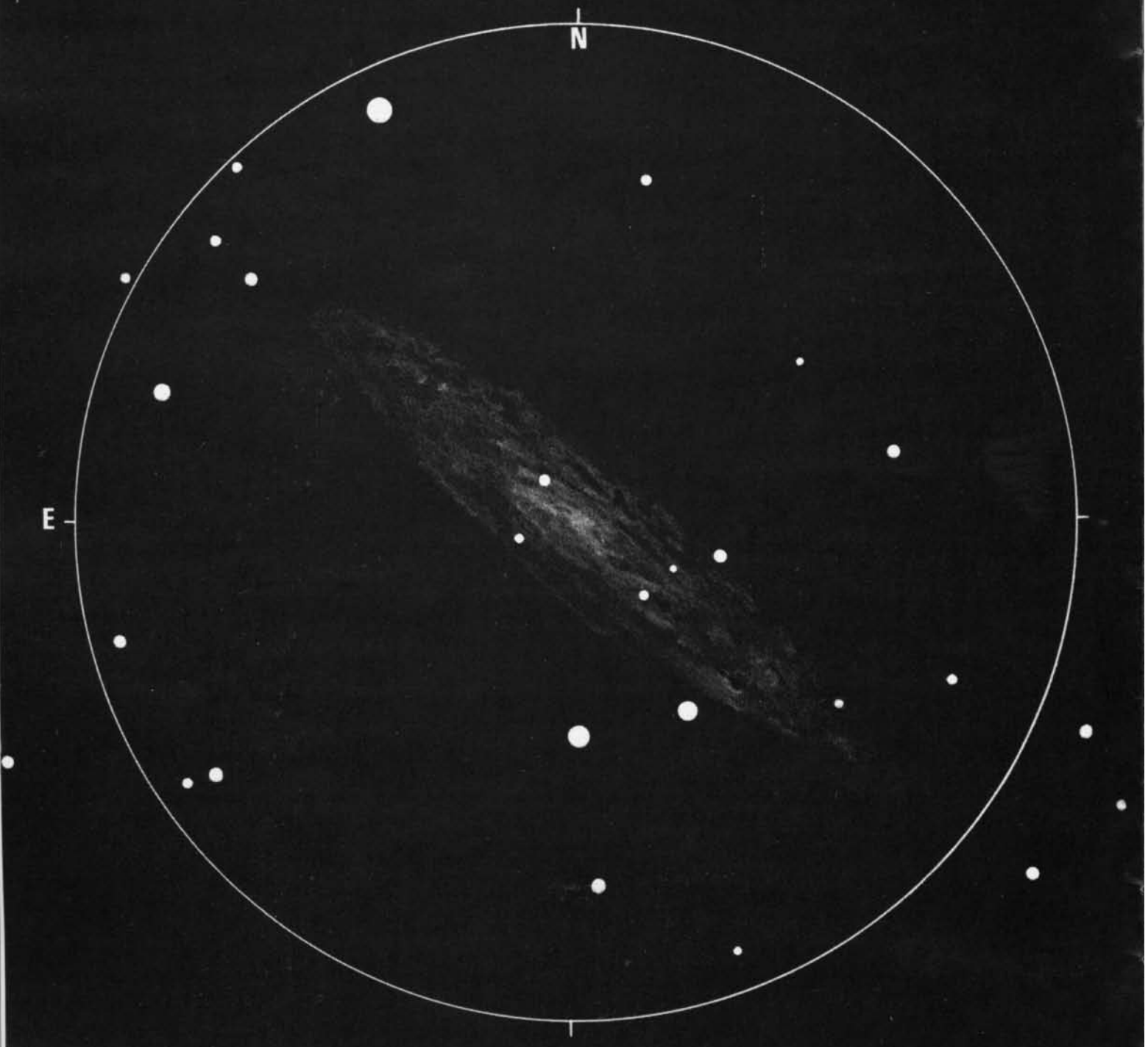
Notes Hya. M83. Visible in binoculars. Bright star-like nucleus. L.M.~15½.
Sequence: MNRAS 167, 13, 1974. R. Wood, P.J. Andrews.

S.P. Chart No. 12
Scale: 10″ = 1mm.

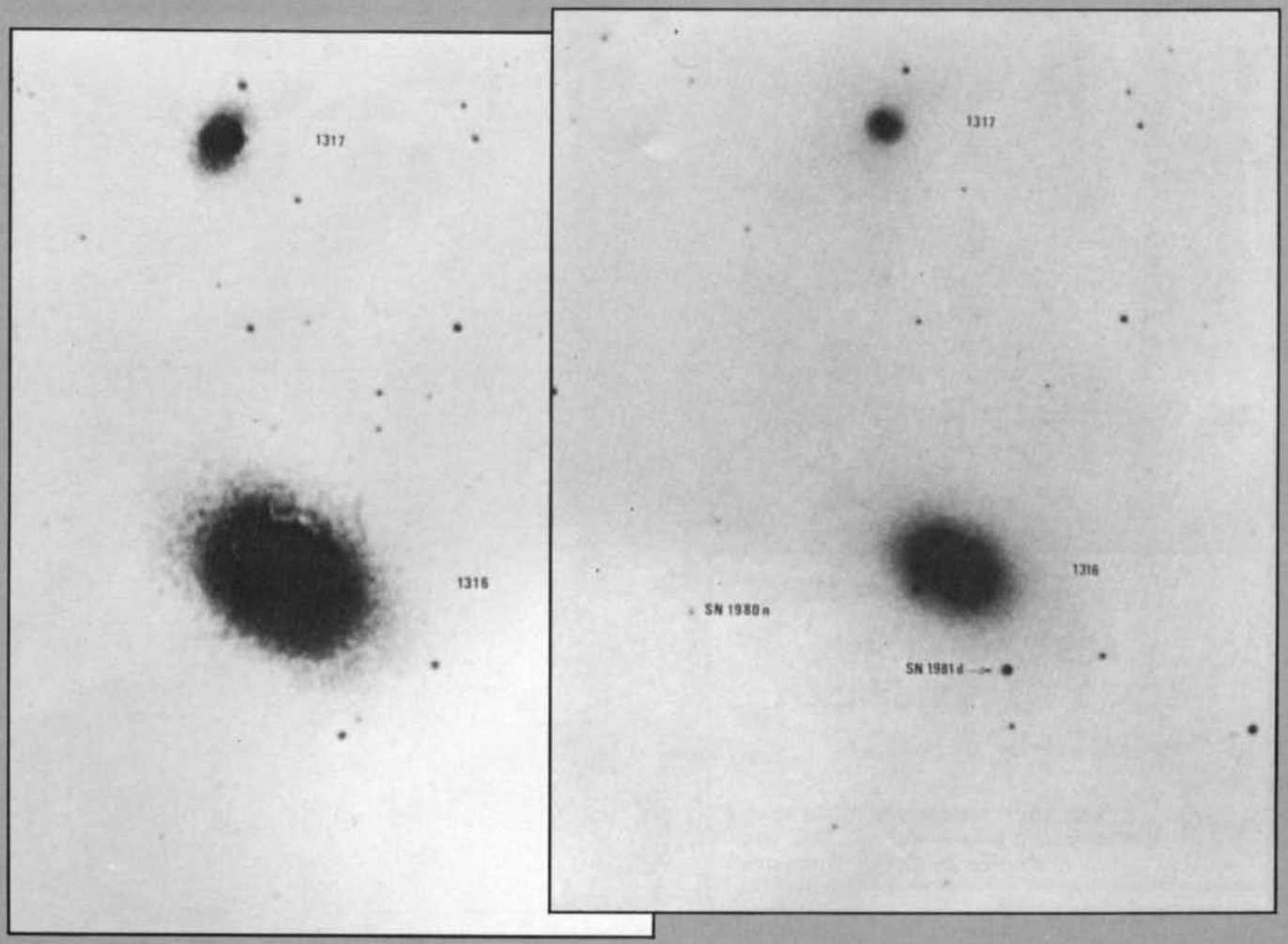
NGC 253

Mag. 7.0
Dim. 24″ x 6.3′

R.A. (1950) 00 45.1 DEC. −25 34
(2000) 00 47.5 −25 18



Notes Scl. 'The Silver Coin Galaxy.' H1^5. Many bright knots involved. L.M. ~ 14½.



Left: Unlike M 83 which is seen face-on, we observe NGC 253 in Sculptor only some 11° above its galactic plane. The strong foreshortening reduces much of the detail that the galaxy shows, but since it is a spiral galaxy, it offers good prospects for supernova-hunters. This chart and the one on the previous page were done by Gregg Thompson for the visual supernova search program. Above: Before and after — two supernovae appeared in spiral galaxy NGC 1316 (in Fornax) at the same time! Supernova 1980n hadn't yet faded when 1981d burst on the scene. Photos by Gregg Thompson.

the sky bright enough to warrant visual searches — namely those in the *Revised New General Catalogue* brighter than magnitude 11.5. Only a few dwarf galaxies and a couple of spirals lying in extremely rich Milky Way star fields were excluded, and some 12th magnitude galaxies in nearby clusters of galaxies were included. We've set ourselves the task of making 225 charts which would contain over 300 relatively bright galaxies. At present, the mapmaking program is not complete, and commercial publication is at least a year off — but we're well under way.

Initial experience has shown that an important quality for a chart is a common scale for quick and accurate measurement of the position of a suspected SN relative to the nucleus of a galaxy. To achieve this, all of the galaxies selected for the charts were copied from the Schmidt Sky Survey plates with a macro lens, and 8″x10″ enlargements made to a uniform scale of 10 arc seconds per millimeter (10″/mm). (M33 is at 20″/mm; M31 is at 10″/mm on five charts.) This scale results in a chart diameter which is comparable to the field of view in most amateur telescopes at about 50x — half a degree.

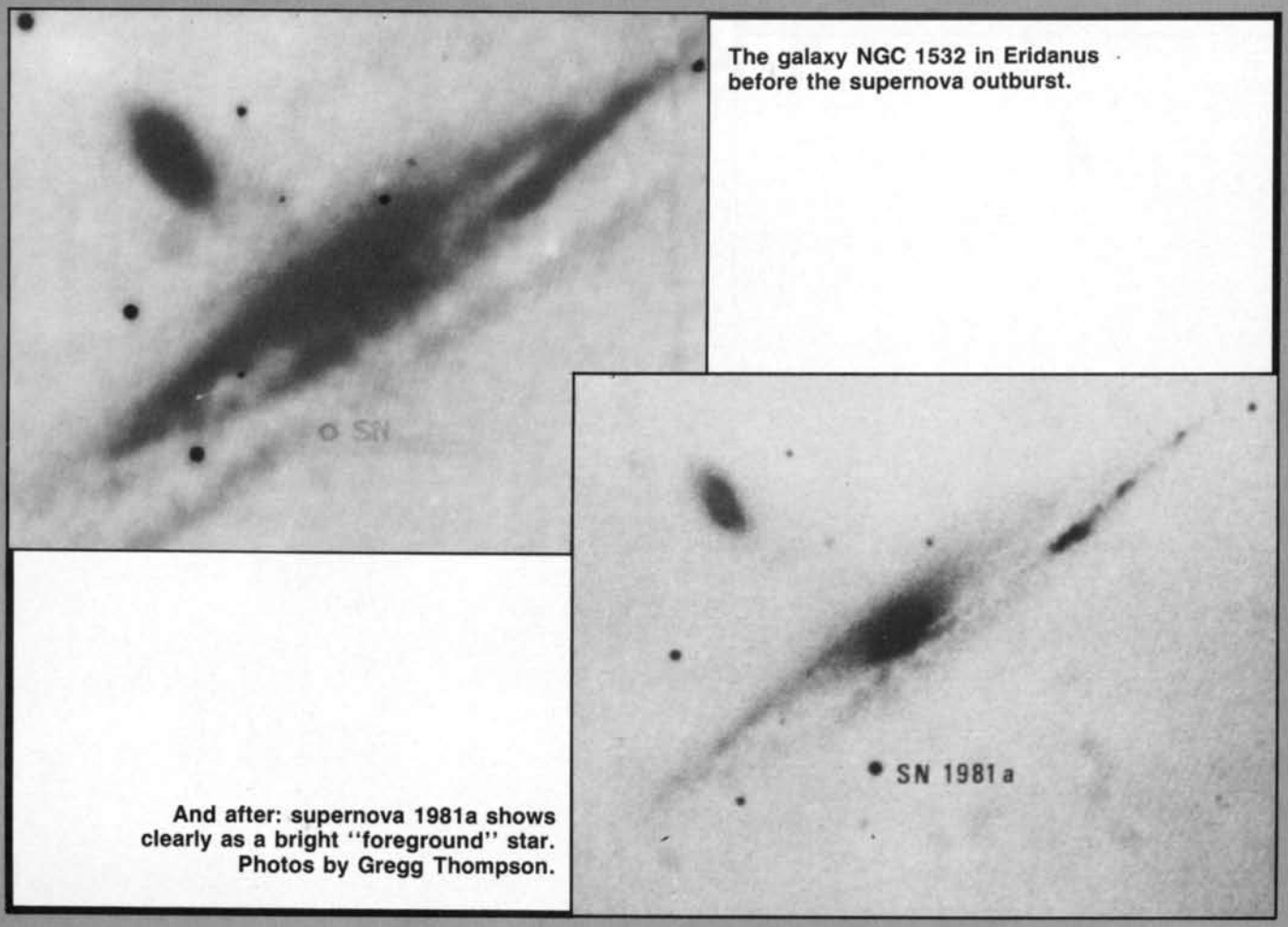
The Survey plate enlargements provide a base on which we trace all stars visible to a particular limiting magnitude (the limits of the charts range between 14.5 and 16.0). The tracings are made at the telescope on a light box so we can adjust photographic magnitudes to comply with visual appearance. This also lets us plot stars hidden in the overexposed regions of galaxies on the Schmidt plates.

To prevent recording a genuine SN as a field star during the initial tracing, we recheck the charts several times at intervals. In addition, charts are sent off to other observers for independent checks. After checking, the tracings are later transformed into the finished artwork. In all, scopes of 8-inch to 24-inch apertures are in use.

Each chart has a circle with a diameter of one-half degree at a scale of 10″/mm. North is at top for galaxies with southern declinations and conversely for galaxies with northern declinations — this reduces the need to read the charts upside down when observing. The intersection of lines drawn through the cardinal points indicates the center of a particular galaxy. Charts containing more than one galaxy show individual cardinal lines.

When an SN is discovered or suspected, the observer needs to be able to pinpoint its position. One way to achieve this is to construct a set of imaginary lines, each connecting two field stars and each passing through the general area in which the SN is. When plotted, a suspected SN's position can be measured in millimeters from the nucleus of its parent galaxy — first in right ascension, then in declination. Knowing the scale of the chart, you easily convert the distance into arc seconds.

The stellar magnitudes approximate their visual appearance and are given in 0.5 magnitude increments. The galaxy is rendered in half-tone so that the stars can be identified easily, even if they appear within bright regions of a galaxy. We've put in galactic detail in excess of that seen visually so you can spot bright HII regions or star clouds which could be taken for an SN by mistake. For the outer regions of a galaxy, the faint halos (as seen on deep Schmidt Plates)



The galaxy NGC 1532 in Eridanus before the supernova outburst.

And after: supernova 1981a shows clearly as a bright "foreground" star. Photos by Gregg Thompson.

have been portrayed where possible.

When we began, the Skalnate Pleso *Atlas of the Heavens* was the most practical finder chart available and the charts indicate which "S.P." map to use. Since then, however, the *AAVSO Variable Star Atlas* and the *Sky Atlas 2000.0* have come out and are equally useful as finder charts. Accordingly, for each object on the charts, the handbook (see below) lists the proper plate to use in any of the three atlases.

The charts list 1950.0 and 2000.0 coordinates for each primary galaxy. Galactic magnitudes come from the *RNGC*, while the dimensions are those shown in de Vaucouleurs' *Catalogue of Bright Galaxies*. Chart notes include the constellation in which the galaxy lies, the galaxy's common name or other designation (if any), any peculiar characteristics within it (e.g.; a starlike nucleus or bright knots), special instructions to the observer ("chart xyz joins to the south" or "search entire field"), the approximate limiting magnitude, the estimated distance modulus — the difference between an object's apparent magnitude and its absolute magnitude — of the galaxy, and the maximum expected brightness of a SN.

We plan to print the charts in reverse (white stars on black background) on a semi-translucent stock. This will enable them to be used effectively at the telescope when placed on a dimmer-controlled light box. A black sky version will affect dark-adaptation less than a white sky would. If you fiddle around with the dimmer on the light box, you can get a remarkably close approximation to the galaxy and its field stars.

We are also working up a 100-page illustrated handbook to accompany the charts. This will give a detailed explanation and provide various tables of data and a guide for establishing a serious observing program. It also covers observing methods, observational bias, statistical analysis of negative and positive observations, and the procedures for reporting any SN discoveries. Magnitudes, dimensions, coordinates, galaxy type, position angle of the major axis, distance modulus, and number of SN discovered will also appear for all galaxies (including companion galaxies).

With current trends in SN searches, it's quite possible that many bright SN are occurring unnoticed. After distributing the charts worldwide, we hope to coordinate a multi-national galaxy surveillance program of regular patrols. Given enough participants, the amateur supernova surveillance program should guarantee that if an SN appears in a charted galaxy and is bright enough for visual observation, it *will* be detected. A well-coordinated search should also ensure that all galaxies are observed at least two or three times a month — the greater the frequency of observations, the greater the opportunity of discovering an SN at the time of its greatest astrophysical interest — "on the rise."

To date, most of the time spent on the program has been in making charts. Nevertheless, a few amateurs have been searching and checking photocopies of completed charts. Since December 1980, Robert Evans has been credited with four visual discoveries, the first ever to do so. Although not credited officially with the discoveries, Evans, James Bryan, P. Mitropoulos, and G. Summy independently discovered five other SNs prior to their announcement. These discoveries clearly demonstrate the worth of the program. Telescopes of 6-inches' aperture or larger, a set of search charts, and some persistence are all it takes to make supernova observations of real astrophysical significance.

Gregg Thompson lives in Australia, and has much experience observing planets, comets, and deep-sky objects. He is the project cartographer. James Bryan lives in Texas, and is an active member of the AAVSO. He is checking the project's charts of Northern Hemisphere galaxies.

Now in paperback

Observing Visual Double Stars

Paul Couteau

"Here's one of the most important books ever published for the dedicated stargazer—and in an important branch of observational astronomy. . . . In eight chapters, Couteau covers everything a telescope owner needs to know about double star observing . . . it also gives you a sense of purpose and urgency about your nightly vigils. Even now, many close binaries are passing unobserved through critical phases of their orbits—potentially priceless data lost for lack of observers."
—Astronomy

Topics cover the history of discovery and observations, techniques of micrometer measurement, data reduction, orbit computation, and much more. There is also a catalog of 744 pairs of stars suitable for small telescopes which contains the latest available position angles and separations for each object.
$8.95

For ordering information, write

28 Carleton Street
Cambridge, MA 02142

THE MIT PRESS

NEW ENGLAND ASTRO-OPTICS

Your one-stop source for

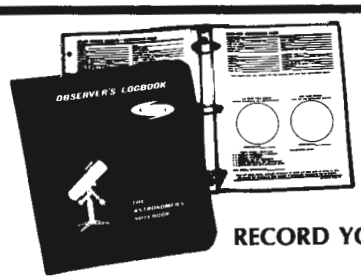
QUESTAR — MEADE
TELE VUE — COULTER

free literature

P.O. Box 834
Simsbury, CT 06070
(203) 658-0701

or Source TCU685 MNET 70055,205

STATEMENT OF OWNERSHIP, MANAGEMENT, AND CIRCULATION (Required by 39 U.S.C. 3685). 1. Title of publication: DEEP SKY magazine. 1A. Publication No.: 07353073. 2. Date of filing: October 1, 1983. 3. Frequency of issue: quarterly. 3A. Number of issues published annually: 4. 3B. Annual subscription price: $10.00. 4. Location of known office of publication: 625 E. St. Paul Ave., Milwaukee, WI 53202. 5. Location of the headquarters or general business offices of the publishers: 625 E. St. Paul Ave., Milwaukee, WI 53202. 6. Names and complete addresses of publisher, editor, and managing editor: Publisher, Robert A. Maas, 625 E. St. Paul Ave., Milwaukee, WI 53202; Editor, David J. Eicher, 625 E. St. Paul Ave., Milwaukee, WI 53202; Managing Editor, Katherine Bond, 625 E. St. Paul Ave., Milwaukee, WI 53202. 7. Owner: AstroMedia Corp., 625 E. St. Paul Ave., Milwaukee, WI 53202, whose owners are: David L. Walther, 625 E. St. Paul Ave., Milwaukee, WI 53202; Christopher Walther, Elizabeth Walther, Jonathon Walther, Jennifer Walther, Mark Walther, 625 E. St. Paul Ave., Milwaukee, WI 53202. 8. Known bondholders, mortgagees, and other security holders owning or holding 1% or more of total amount of bonds, mortgages, or other securities: none. 9. For completion by nonprofit organizations authorized to mail at special rates (Section 411.3, DMM only): not applicable. 10. Extent and nature of circulation: 10A. Total number copies printed (net press run): average number copies each issue during preceding 12 months: 3,123; actual number copies of single issue published nearest to filing date: 3,200. 10B. Paid circulation: 10B1. Sales through dealers and carriers, street vendors and counter sales: average number copies each issue during preceding 12 months: 62; actual number copies of single issue published nearest to filing date: 161. 10B2. Mail subscription: average number copies each issue during preceding 12 months: 2,445; actual number copies of single issue published nearest filing date: 2,386. 10C. Total paid circulation (sum of 10B1 and 10B2): average number copies each issue during preceding 12 months: 2,507; actual number copies of single issue published nearest filing date: 2,386. 10D. Free distribution by mail, carrier, or other means, samples, complimentary, and other free copies: average number copies each issue during preceding 12 months: 27; actual number copies of single issue published nearest filing date: 31. 10E. Total distribution (sum of C and D): average number copies each issue during preceding 12 months: 2,534; actual number copies of single issue published nearest filing date: 2,417. 10F. Copies not distributed: 10F1. Office use, left over, unaccounted, spoiled after printing: average number copies each issue during preceding 12 months: 589; actual number copies of single issue published nearest to filing date: 783. 10F2. Returns from news agents: average number copies each issue during preceding 12 months: 0; actual number copies of single issue published nearest filing date: 0. 10G. Total (sum of E, F1 and F2 — should equal net press run shown in A): average number copies each issue during preceding 12 months: 3,123; actual number copies of single issue published nearest filing date: 3,200. 11. I certify that the statements made by me are correct and complete. Signed Dennis Wilk, Comptroller.

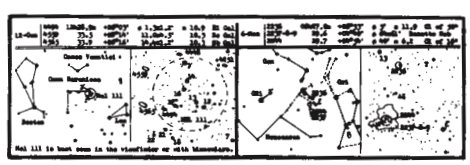


OBSERVER'S LOGBOOK

Only **$16.95**
Foreign add $4.00
Airmail add $20.00

RECORD YOUR OBSERVATIONS

CONTAINS 100 OBSERVING FORMS: Choice of 100 Solar System Forms (for planets, Sun, Moon, comets, etc.) or 100 Deep-Sky Forms, or 50 of each. Comes with Messier Catalog & Selected NGC List, plus instructions. Large dew-resistant binder, blue with silver lettering.



INDEX CARD FINDER CHARTS

Made especially for use at the telescope!

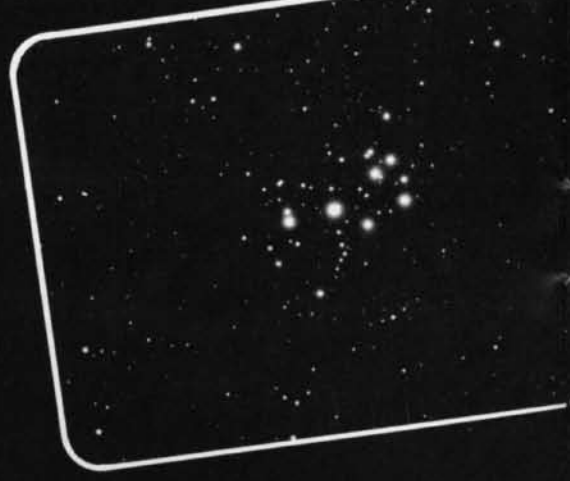
SET I — THE MESSIER OBJECTS.....$7.50
SET II — THE FINEST NGC OBJECTS.....$7.50
SET III — FINEST DOUBLE STARS.....$7.50
SET IV — THE FINEST NGC, Part B.....$7.50

2 or more **$7.00** ea., 4 or more **$6.50** ea. Outside U.S.A. add 20% for airmail. *Astro Cards* show the locations of the best galaxies, nebulae, star clusters, and double stars on handy 3 x 5 data cards. Each set has 75 charts.

Send 37-cent stamp for FREE CATALOG. PA residents add 6% tax. FOREIGN ORDERS: add 20% to total for postage.

Astro Cards®
P.O. Box 35, Natrona Heights, PA 15065
Phone: 412-295-4128

PIGGY-BACKING Your Camera for Astro-photography

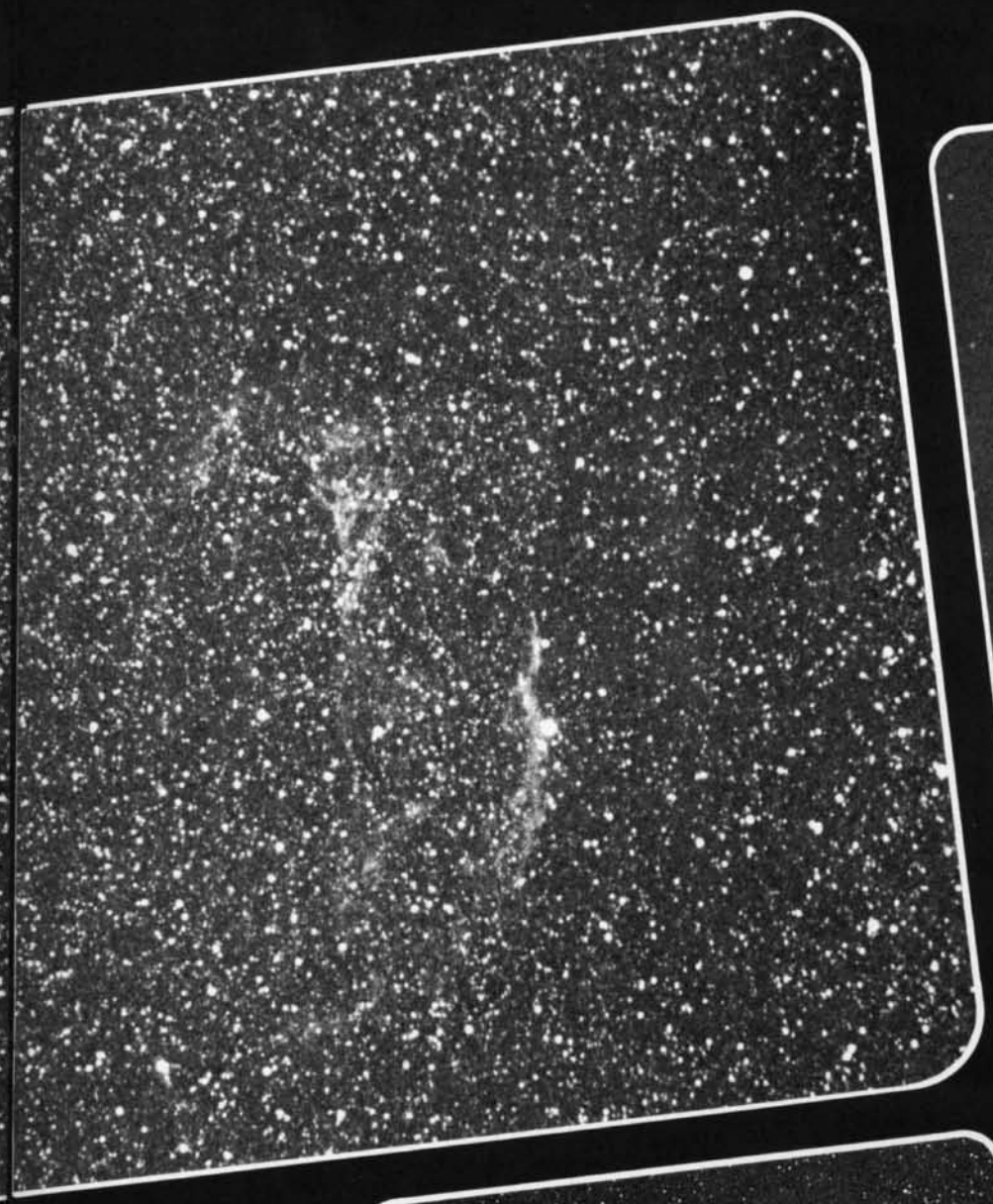


by David Healy

In DEEP SKY 4, I explained how to polar-align a mounting for deep-sky astrophotography — the first and probably most critical step in making good deep-sky photographs. I also described my first deep-sky photo, a catastrophic shot of M31, the Andromeda Galaxy: the telescope was not polar-aligned, the exposure was unguided, the camera was out-of-focus, I used the wrong film, the focal ratio was too high, the telescope's corrector plate dewed up, the exposure time was too short, the galaxy was too big to fit into the telescope's field of view, and I was shooting color film from a light-polluted area. These blunders might serve as good subject-headings for "how-to" or, more precisely, "how-not-to" discussions of deep-sky photography.

Photographing Large Deep-Sky Objects

"The galaxy was too big to fit into the telescope's field of view." M31's full extent is still a matter of debate and definition, but good amateur photographs show it to be at least 2° and possibly 3° along its longer dimension — equal to four or six Full Moons. A typical telescope's field of view is usually no more than 1°, suggesting that a through-the-telescope shot of M31 records only the nucleus. This leaves you unable to make a good photo of M31 with your scope, unless you make a composite from several exposures. The same problem happens with other large deep-sky targets, such as Milky Way fields, clusters of galaxies, and individual objects like the Double Cluster, M33, the Orion Nebula, M6 and M7, the Pleiades, and others.



Left: A favorite object for backyard astrophotographers is the Veil Nebula in Cygnus. David Healy recorded its two main sections and middle nebulosity with a 135mm f/2.5 lens, 103a-E film, a #92 red filter, and a 45-minute exposure. *Above*: Employing a 300mm f/4 lens and a #92 filter, David Healy recorded subtle detail in M42, the Orion Nebula. He made the 10-minute exposure on 103a-E emulsion.

Left: Fred Mendenhall used a 135mm f/2.8 telephoto, Tri-X film, and a 15-minute exposure to capture the Pleiades cluster in Taurus. *Right*: With his 6 x 7 cm format camera and 200mm f/4 lens, Jim Riffle photographed the elusive California Nebula in Perseus. He used 103a-E emulsion and an R-2 filter for the 20-minute exposure.

Above: Using a 400mm f/6.3 telephoto lens and hypersensitized TP 2415 film, Jack Marling made this finely detailed portrait of M8 and M20 in Sagittarius. The open cluster M21 lies at top left and the globular NGC 6544 lies at lower left. Made with a minus violet filter, the exposure lasted for 20 minutes. *Right Top:* David Healy used a 135mm f/2.5 telephoto to record the Scutum Starcloud and cluster M11. He used 103a-E film and a 12-minute exposure. *Middle Right:* With a 200mm f/3.5 lens and 103a-E film, David Healy photographed the Gamma (γ) Cygni region and nebulosities IC 1318 and NGC 6888. The exposure lasted 24 minutes. *Below Right:* With his 6 x 7 cm format camera fitted with 400mm f/4 telephoto, Jim Riffle made this photo of M31. It is a 20-minute exposure on 103a-E, made with a minus violet filter.

35mm Piggybacking Equipment

Surprisingly, an ordinary 35mm camera can take good photos of all kinds of sky areas and deep-sky objects. That telephoto lens you use at football games is also a fast, wide-field photographic refractor if it can be "piggybacked" on a clock-driven equatorial mounting or telescope. So if you polar-align and drive your telescope and rig up or buy a mount for the camera, you are equipped for piggyback astrophotography.

Deep-sky objects are so dim that they typically require time exposures of five minutes to an hour. And time exposures require cameras that "move with the sky"; otherwise the Earth's rotation causes the images to trail on the film. Long exposure photos, however, permit faint images to build up on the film to the point where faint stars, galactic detail, and nebular colors invisible even through telescopes get recorded and preserved for a cloudy night. A rather ordinary telephoto lens, in fact, is capable of recording stars a thousand times fainter than the faintest visible to the naked eye.

Fields of View

With a 35mm camera and interchangeable lenses, you can photograph a variety of sizes of star fields. A 50mm "normal" lens covers a large field of 28° x 40°. A 135mm telephoto lens covers about 10° x 15°, and a 400mm telephoto covers about 4.6° x 6.9°. In general, the field of your lens is given by the following formula:

Field coverage (in degrees) = 2 arctan (film format dimensions ÷ twice the system's focal length).

So if, for example, your lens is a 28mm wide-angle, and your film format dimensions are the standard 35mm (24mm x 36mm), its sky coverage is: 2 arctan (24 ÷ 56) = 46.4° vertically, and 2 arctan (36 ÷ 56) = 65.5° horizontally.

Lens Defects

When used at full aperture, virtually all lenses suffer from coma — star images near the edge of the frame shaped like comets or strange looking blobs. Coma can usually be curbed or reduced by stopping-down the lens to a higher focal ratio. A lens that behaves poorly at f/1.8 usually produces much better photos at f/2.5 or so, and sharp images at f/4. How a particular lens behaves wide open is hard to predict in advance — though price is a useful but not infallible guide, since on occasion inexpensive lenses pass the full aperture "star test" beautifully. The disadvantage of stopping down a lens, of course, is that exposure times must be increased. Suppose you shoot an object for five minutes at f/1.8 and come up with lousy star images on part of the frame. You go back and photograph the same object at f/2.5, but now you'll have to expose for 10 minutes or more to record as many stars.

Guiding

If your telescope is accurately polar-aligned, its clock drive is smooth, and you want to take wide-field star shots, you can probably take brief piggyback astrophotos without guiding. But you won't want to rely on it: certain inherent problems with alignment and drive regularity make a drive corrector and illuminated reticle eyepiece desirable and in many cases necessary. A drive corrector is simply an electronic "black box" that speeds up or slows down the telescope's r.a. drive motor using fast and slow buttons. Guiding consists of correcting small tracking errors — caused either by imprecise polar alignment, fluctuations in the drive current, or refraction — by depressing the fast/slow buttons and by using the dec. slow motion to stop potential errors before they become large enough to affect the photograph. Place the guiding eyepiece in your telescope, find and center a suitable guidestar — one that keeps the object you want to photograph in the camera's field of view. Then open the camera's shutter, keep track of the exposure's running time, and keep the guidestar centered on the crosshairs for as long as you collect photons.

A 32-minute exposure with a 200mm f/2.8 telephoto resulted in this image of the North America and Pelican Nebulae in Cygnus. Photo by Jack Marling, who used hypersensitized TP 2415 film and an Hα pass filter.

Using a standard 50mm f/2 lens and 103a-E emulsion, Dean Salmon photographed three bright deep-sky objects together in one film frame — galaxies M31 in Andromeda and M33 in Triangulum, and open cluster NGC 752 in Andromeda. He used a #25A filter for the 45-minute exposure.

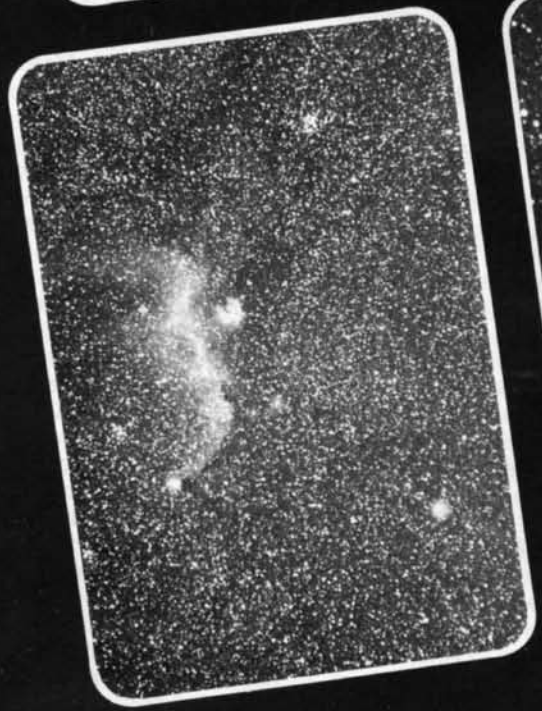
Anti-Murphy Rules

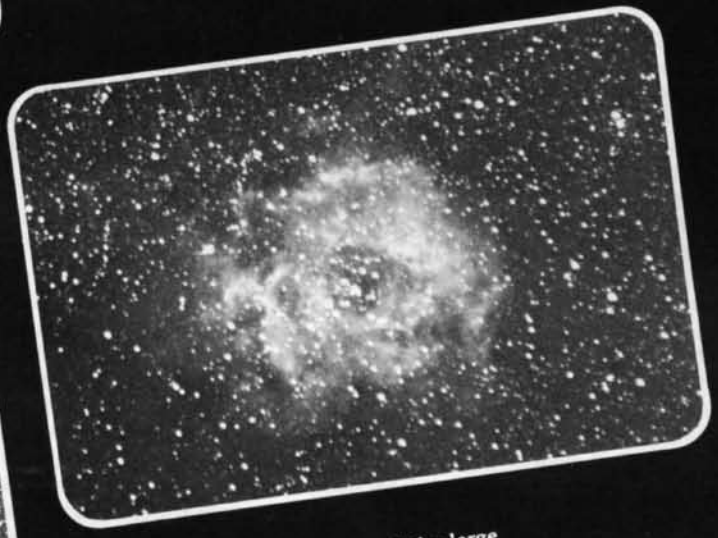
In piggyback astrophotography, as with any other method, Mr. Murphy of Murphy's Law ("if anything can go wrong, it will") reigns supreme. A few simple rules prevent wasting a good deal of film and an unnecessary rise in blood pressure when the film comes back from development. I know because I've made — at one time or another — all of the following mistakes. If *you* don't succeed at first, don't be discouraged — these rules are *not* simple when you are trying to operate complicated equipment in the dark:

1) Make sure there is film in the camera. 2) Squeeze off a couple of ordinary snapshot frames at the beginning of each roll so your film processor won't cut your dim astronomical slides across the middle. 3) Make sure that the lens-plus-camera combination is firmly secured to the telescope and is pointing where you want it to be. Centering a bright star in both the camera's finder and the scope's eyepiece is a good method of assuring lineup. 4) Be sure the lens cap is off and use a lens hood to prevent dewing and glare from stray lights. If the lens hood is not enough, periodically blow the dew off with a hair dryer. 5) Focus the lens at infinity. Set the camera for the proper f/stop. Set the camera's shutter to "B" or "T" and hold the shutter open for the proper time with a locking cable release. A kitchen timer is ideal for timing exposures. 6) Wind the film. 7) Fill in the pre-planned technical data sheet noting object photographed, time, date, sky conditions, exposure time, and camera settings.

The last item is more important than you might think. When the first pictures come back and are disappointing — and your first attempts will almost invariably be short of spectacular — you can use the technical notes to narrow down the mistakes. If you keep at it, one day a few of your piggyback photos will come back perfect: each star a point of light, each filament of nebula clearly resolved. You will capture on film objects that are unbelievably distant, as they looked many years in the past. You are on your way!

55 Lake Road
Manhasset, NY 11030





Left: Jack Marling photographed the large emission nebula IC 2177 in Canis Major with a 200mm f/2.8 telephoto and a 60-minute exposure. He employed hypersensitized TP 2415 film and an Hα pass filter. The open cluster M50 lies at upper right in the photo. *Above*: With a 200mm f/2.8 telephoto and a 60 minute exposure, Jack Marling photographed the Rosette Nebula in Monoceros. The film was hypered TP 2415; he used an Hα pass filter.

The Finest Double Stars of Winter

by Glenn F. Chaple, Jr.

For the double star enthusiast, winter is frustrating. Not only is it cold, but the seeing is often abominable. Sooner or later, however, you'll encounter a winter night when the telescope performs to its theoretical limit of resolution. What can you see on such a magical evening?

The following are the finest 25 double, triple, and multiple stars of winter. All come from between 2h and 8h in right ascension and north of −40° declination.

Gamma (γ) **Andromedae** 2h 0.8m (1950) +42° 06′ (magnitudes 2.3, 5.1; separation 10.0″; position angle 63°; 1962). Known as Almach, this is a fine pair for colors: gold and blue-green to rival Albireo. For big-scope owners, the secondary itself is double: with a period of 61 years, this magnitude 5.5 and 6.3 duo is now at its widest. The separation is just 0.55″ in p.a. 110°.

Iota (ι) **Trianguli** 2h 9.5m, +30° 04′ (mags. 5.2, 6.6; sep. 3.9″; p.a. 72°; 1955). A beautiful yellow and blue double. In the same low-power field is Σ232 (mags. 7.5, 7.5; sep. 6.6″; p.a. 246°; 1955). An exquisite sight!

Iota (ι) **Cassiopeiae** 2h 24.9m, +67° 11′ (mags. 4.7, 7.0, 8.3; sep. 2.4″, 7.3; p.a. 235°, 114°; 1980, 1958). A grand triple, it is difficult for 3-inch scopes, because of the closeness of the 4.7 and 7.0 mag components.

Gamma (γ) **Ceti** 2h 40.7m, +3° 02′ (mags. 3.7, 6.2; sep. 2.7″; p.a. 295°; 1961). So far, this duo has eluded my 3-inch reflector. Wide enough to be resolved, the large magnitude difference complicates things. Look for a 10th mag star about 15′ away to the northwest. This star, the red dwarf BD+2° 418, is also a member of the Gamma Ceti system.

Eta (η) **Persei** h 47.0m, +55° 41′ (mags. 3.9, 8.6; sep. 28.3″; p.a. 300°; 1932). As with most pairs that show colors, Eta's hues are yellow and blue. A 10th magnitude companion lies 67″ distant in p.a. 268°.

Epsilon (ε) **Arietis** 2h 45.4m, +21° 08′ (mags. 5.7, 6.0; sep. 1.4″; p.a. 203°; 1966). An ideal test for a 3-inch scope. Both components appear white.

Theta (θ) **Eridani** 2h 56.4m, −40° 30′ (mags. 3.4, 4.5; sep. 8.2″; p.a. 88°; 1952). Though Acamar lies just south of our −40° declination limit, I had to include it. Described as "one of the gems of the southern sky," Theta Eri can be seen from much of the U.S. and southern Canada.

f Eridani 3h 46.6m, −37° 47′; (mags. 4.9, 5.4; sep. 7.9″; p.a. 212°; 1957). Another far-south pair and a bit outclassed by Theta Eri, this is nevertheless a fine sight. Both components are white.

32 Eridani 3h 51.2m, −3° 06′; (mags. 5.0, 6.3; sep. 6.8″; p.a. 347°; 1955). This double is noted for its color contrast, described a century ago by Webb as "topaz, bright green."

Σ485 Camelopardalis 4h 03.4m, +62° 12′; (mags. 6.1, 6.2; sep. 18.1″; p.a. 304°; 1957). Often overlooked in a sparse region of sky, this pair lies in the open cluster NGC 1502 and is surrounded by a glittering array of 8th and 9th magnitude stars.

Omicron² (o^2) **Eridani** 4h 13.0m, −7° 44′ (mags. 4.5, 9.4; sep. 82.8″; p.a. 105°; 1940). The fainter component is one of the few white dwarfs visible in a small scope. Moderate apertures will reveal the 10.8 magnitude red dwarf companion to the white dwarf. This latter pair has an orbital period of about 250 years and is currently near maximum separation of 9″ (p.a. 330°).

Beta (β) **Orionis** 5h 12.1m, −8° 15′ (mags. 0.1, 6.7; sep. 9.4″; p.a. 202°; 1925). This is Rigel — and a real small-scope challenge! Can you spot the companion in the brilliant glare of the primary? I've done it — once — with a 3-inch, but it's fairly easy with a 6-incher.

Eta (η) **Orionis** 5h 22.0m, −2° 26′ (mags. 3.6, 5.0; sep. 1.5″; p.a. 77°; 1966). This eludes my 3-inch, but it's a nice sight in my Odyssey I, stopped down to 5 inches.

Theta¹ (θ^1) **Orionis** 5h 33.0m, −5° 27′ (mags. 5.4, 6.8, 6.8v, 8.0v; seps. 13.3″, 13.1″, 16.8″; p.a. 61°, 311°, 342°; 1925). The famous Trapezium, in the heart of the Orion Nebula (M 42), is the finest multiple star in the heavens. If the air is steady, a 6-incher will add two more stars of 11th magnitude. And 2′ eastward and still in the Great Nebula is Theta² Ori — a 52.5″ pair with magnitudes of 5.2 and 6.5.

Iota (ι) **Orionis** 5h 33.0m, −5° 56′ (mags. 2.7, 6.9; sep. 11.4″; p.a. 141°; 1932). From the Trapezium, drop southward just half a degree; Iota's primary is an O-type star. In the same field 8′ southwest is Σ747 (mags. 4.7, 5.6; sep. 35.7″; p.a. 223°; 1924). Immediately to its west is Σ745 (mags. 8.5, 8.7; sep. 28.6″; p.a. 347°; 1918). All three pairs, plus Theta¹ and Theta² Ori can be captured in a 1° field.

Sigma (σ) **Orionis** 5h 36.2m, −2° 36′ (mags. 3.7, 10.3, 7.5, 6.5; seps. 11.1″, 12.8″, 41.6″; p.a. 237°, 84°, 61°; 1936, 1934, 1934). A fine multiple system, though the 10th magnitude star is usually invisible in small scopes. Three and a half degrees northwest is the faint triple Σ761 (mags. 7.9, 8.2, 8.7). The latter two members form an 8.5″ pair some 68″ south of the main star.

Zeta (ζ) **Orionis** 5h 38.2m, −1° 57′ (mags. 1.9, 4.2; sep. 2.5″; p.a. 164°; 1957). *Norton's Star Atlas* calls this a test for 2-inch scopes, but I had difficulty splitting it with an Odyssey I stopped to 5 inches. Zeta Ori is accompanied by a 10th magnitude star 58″ to the north. With a 6-inch scope, look for the nebula NGC 2024 15′ to the east.

Gamma (γ) **Leporis** 5h 42.4m, −22° 28′ (mags. 3.6, 6.2; sep. 94.9″; p.a. 351°; 1959). This pair is easy for binoculars and small scopes.

Σ817 Orionis 5h 52.2m, +7° 02′ (mags. 8.2, 8.3; sep. 18.5″; p.a. 73°; 1925). What makes this faint pair so charming to me it its proximity (20′ south) to brilliant Betelgeuse.

Beta (β) **Monocerotis** 6h 26.4m, −7° 00′ (mags. 4.5, 5.2, 5.6; seps. 7.3″, 10.0″; p.a. 132°, 124°; 1955). An incredible sight in a 3-inch at 120x. All its components appear white.

12 Lyncis 6h 41.8m, +59° 30′ (mags. 5.3, 6.2, 7.2; seps. 1.8″, 8.7″; p.a. 101°, 308°; 1959). Another grand triple — though harder for small-aperture instruments.

Alpha (α) **Canis Majoris** 6h 43.0m, −16° 38′ (mags. −1.4, 8.7; sep. 8.7″; 38°; 1984). Sirius is the ultimate light test: virtually impossible in scopes smaller than 6 inches, and not easy with twice that. Sirius rapidly closing to just 2.7″ in 1993. Catch it while you can!

h3945 Canis Majoris 7h 14.5m, −23° 13′ (mags. 4.8, 6.8; sep. 26.6″; p.a. 55°; 1959). This favorite pair has rich gold and blue colors that class it with Almach and Albireo. Absolutely beautiful!

Alpha (α) **Geminorum** 7h 31.4m, +32° 00′ (mags. 2.0, 2.8; sep. 2.5″; p.a. 87°; 1984). Castor's white components are widening from a minimum separation of 1.8″ in 1969. The orbital period is perhaps four or five centuries. These are, in turn, circled by a 9th magnitude star every 10,000 years or so.

k Puppis 7h 36.8m, −26° 41′ (mags. 4.5, 4.6; sep. 9.9″; p.a. 318°; 1951). A beautiful twin system; both white.

82 South Harbor Road
Townsend, MA 01469

Variable Stars

Observing As Community: The AAVSO

by David H. Levy

On the evening of July 6, 1936, William Tyler Olcott was introducing astronomy to a small group of summer residents at George's Mills, New Hampshire. Olcott loved the stars; he enjoyed lecturing about them, writing poems about them, forming groups of people who could study them. Twenty-five years earlier, Olcott had founded the American Association of Variable Star Observers. The audience listened carefully as the enthusiastic lecturer shared his interest in astronomy. But in the middle of his talk, Olcott suffered a heart attack. His subsequent death stunned the members of his beloved AAVSO.

Today the American Association of Variable Star Observers thrives as a living reminder of Olcott's most ardent hope, that amateur and professional could work closely to further the science of astronomy. Olcott felt that the relationship would benefit both groups — the amateur, who loves to follow the behavior of his favorite variable star, and the professional astronomer, who needs to know what that star is doing in order to plan his precious observing moments at the dome of a large observatory or with an orbiting telescope.

What is the AAVSO? Despite its 73-year existence, many amateur astronomers see the organization as being somewhat mysterious. "Variable star observers live in a world all their own!" If I had a dollar for every time I heard a comment like that, I'd be able to buy my own variable stars.

In reality, the AAVSO consists of a number of extraordinary people who have found a special motivation for their astronomical committment. These are people who began like you and me, with small telescopes, looking at the Moon, double stars, and deep-sky objects. Some have found such satisfaction in observing variables that they have excluded all else. But most variable star observers today are also deep-sky people who show those stunning photographs of galaxies at club meetings, the avid planetary observers, and the volunteers for public star parties. And the AAVSO, with its specific and challenging programs, provides direction to some of the observing activities these people undertake. (For membership information write to AAVSO, 187 Concord Avenue, Cambridge, MA 02138.)

Aside from being active in many other fields, I am a variable star observer. When I began, back in 1966, I was a bit headstrong with the excitement of discovery, of watching something that was not just there, but actually changing. I was also fresh from my first reading of Leslie Peltier's outstanding autobiography, *Starlight Nights*. Here was a man who loved variables just as I wanted to. Here was a man whose book had captured the real meaning of what it was like to be an observer. And here was a man who devoted much of his life to observing for the AAVSO.

Seventeen years later, I still am addicted to the magic of what the AAVSO stands for. For me, variables offer a special way to commune with the stars, a unique opportunity to deal with each star in your program on its own terms. But the AAVSO is more than that. In addition to its main purpose of gathering and analyzing the data that we observers gather, it also offers programs in nova searching and solar observing. And what's more, it is also a very social group whose members gather twice a year to share tales about their experiences both here on this planet and with the stars.

In the spring of 1980, the AAVSO met during a raging thunderstorm in Houston. A year later, members gathered among the domes and mountaintops of Tucson. And each fall, the group meets somewhere in Massachusetts, often in the Boston area. At the helm of the AAVSO is Janet A. Mattei, who this year celebrates 10 years as director. Overseeing the thousands of observations that pour in each year, organizing the two annual meetings, and dealing with a gargantuan amount of correspondence with members, interested school children, and professional astronomers require every ounce of Janet's enthusiasm.

One of Janet's principal tasks is convincing potential observers that variable star work is challenging, but not too difficult. Using specially prepared charts, which AAVSO chartmakers have produced for most of a century, observers with 3- or 4-inch scopes can make significant contributions to the field. And of course, like any other branch of amateur astronomy, nobody needs a degree in astrophysics — just a wish to follow and understand the behavioral pattern of a star.

Each new AAVSO observer receives a package of about 10 introductory charts. For over 50 years the set has included maps of R Leonis, a long period variable located not far from Regulus. Experienced and novice observers alike watch this Mira-type star, and Leslie Peltier began his 60-year string of 140,000 variable star observations with a single look at R Leonis. Other veteran observers started with different objects, some of them telescopic stars, others perhaps brighter stars visible to the unaided eye.

This issue, let's look at a dwarf nova. In years gone by, all dwarf novae were called U Geminorum variables, but recently, due to the popularity of SS Cygni, there is now a question as to whether SS Cyg is a U Gem star or whether U Gem is part of the SS Cyg family. (Ah, the problems of trying to satisfy every star!) U Gem (7h 52.1m, +22°08′) spends most of its time at its mimimum magnitude of 14.0, but when it goes into outburst, it can climb within a few hours to 8.9. Use at least an 8-inch telescope to view U Gem, and be patient while you find it, for the rich Gemini starfield in which it is located may make this a difficult process. Also, remember that 14th magnitude pushes the visual limit of an 8-inch.

I particularly enjoy watching U Gem because it reminds me of an exquisite fall afternoon back in 1978. I remember the excitement and sense of rebirth felt by AAVSO'ers at the annual meeting that year. This was when interest in dwarf novae really exploded due to the impending series of HEAO (High Energy Astrophysical Observatory) satellites about to be launched. The most famous of these, HEAO-2, was later called the Einstein Observatory.

We had spent the afternoon listening to papers while the autumn Sun lit up the striking red maple leaves outside the observatory windows. Sitting around me were older people, some of whom had been variable star observers for over 50 years. Shaking his head, one of them said, "I thought that the professionals had all the data they wanted from us. I'm an old man now. Years ago we all were part of the thrill of observing for professionals who needed our work. Then came a long period when we wondered if there was any value at all to what we were doing. Now the old excitement, the freshness, is back again."

Route 7, Box 414
Tucson, AZ 85747

DSM Reviews

Atlas of the Andromeda Galaxy
by Paul Hodge
University of Washington Press
Seattle, 1982
79 pages, 8¾″ x 9″
cloth, $50

Astronomers have made major advances in mapping the sky during the last twenty years. You can now purchase high quality photographic atlases depicting selected deep-sky objects (the *Atlas of Deep Sky Splendors*), the entire sky on a small scale (the *Atlas Stellarum*), the entire sky on a large scale (the Palomar and ESO *Sky Surveys*), or individual objects in detail (*The Small Magellanic Cloud* and *The Large Magellanic Cloud*). Photographic atlases are very nice — they are very reliable, rarely showing plate defects or objects that "aren't there," and show detail rather than just location.

The problem is that, whereas you can go buy the deluxe edition of *Sky Atlas 2000.0* for $35, photographic atlases are much more expensive, ranging from about $40 to over $7,000. This is an artifact of the photographic process itself: as first demonstrated by Barnard's *Atlas of Selected Regions* in 1927, books that use photographic prints for pages are terrifically time consuming and expensive to produce, let alone to market and make a profit from. There were only 700 copies of the Barnard book produced, each with hand-pasted photographic prints on practically each and every page. Some atlases still rely on actual photographic prints (the Palomar *Survey*, for example), but modern printing technology permits high quality halftone reproductions. *Voila*! The problem is solved — everyone interested in astronomy can easily own a photographic record of everything! Well, now the problem shifts to "small press runs": there simply aren't too many people who want to buy a photographic record of the sky, so the expected savings don't materialize.

This is the problem that Paul Hodge faces with his *Atlas of the Andromeda Galaxy*. Co-author of the two atlases on the Magellanic Clouds, Hodge has now produced the third detailed atlas of an extragalactic object. It is a superb work, but its $50 price tag will keep it from reaching most interested amateur astronomers.

The atlas consists of five pages of text and 41 charts, which have scales of 7.6 to 8.8 arcseconds per millimeter (in the nuclear region) to 17.4 arcseconds per millimeter for the rest of the galaxy. The finely detailed negative plates were made with the 4-meter Mayall telescope on Kitt Peak and two wide field "finder charts" appear that were made with the Palomar 1.2-meter Schmidt. An appendix lists film and exposure data.

Mount Wilson Observatory

M31's nucleus photographed with the 100-inch Hooker telescope.

This atlas is a gold mine for locating individual tiny objects in and around M31. It identifies 355 globular clusters, 413 open clusters, 188 stellar associations and 730 dust clouds. Hodge doesn't list magnitudes for the clusters, but sources like the *Master List* and references cited in this book's appendix can provide that information. Astrophotographers can really test their systems with this atlas — stellar objects brighter than 18th magnitude are within the grasp of photographers with large telescopes and fine grain films. If you get the chance to use a large telescope (a 14- to 20-incher), take Hodge's atlas along and point the scope toward M31. Instead of looking at one object, you can look at 100!

This book is for you if a) you don't mind spending a lot for a relatively thin book, b) you observe and/or photograph with a large telescope and are interested in galaxies, c) you have a strong interest in galactic structure, especially in M31, or d) you want a complete astronomical library. If any of the above describes you, buying this book is an excellent investment. If not, try the nearest major metropolitan or college library.

Alan Goldstein
3430 Bryan Way
Louisville, KY 40220

Meade & Celestron
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices. Both Catalogues $3.

HIGH PERFORMANCE TELESCOPES

ASTROPHOTO OF THE MONTH

Horsehead Nebula IC434 and reflection nebulae IC435 (below Horsehead) and NGC 2024. The Horsehead Nebula is seen best with a LUMICON H-Beta Filter. The reflection nebulae are seen best with a LUMICON DEEP-SKY Filter. 20 min. exp. Photo by Dr. Jack Marling using a LUMICON Newtonian EASY-GUIDER, 8"f/4.5 telescope and 2415 film sensitized in a LUMICON Model 300 HYPER-KIT.

LUMICON® FILTERS STOP LIGHT POLLUTION

The **LUMICON DEEP-SKY Filter™** improves both visual and photographic contrast on all deep-sky objects, including galaxies. The **LUMICON UHC Filter™** is for viewing only and yields the highest contrast for planetary and emission nebulae of any filter available today.

Filter Type	UHC	Deep-Sky
For 0.965" eyepieces	—	$49.95
For 1¼" eyepieces	$79.50	$59.50
48mm for 2" eyepieces	$119.50	$99.50
For 2" eyepieces & photography		$99.50
Set, 1¼" UHC & Deep-Sky Filters		$119.50

Selected premium filters ..... add $20
H-Beta Filter, 1¼" ....$69 48mm $119

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photography with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$29.95	$25.00
52, 55, 58, 62mm....	$39.95	$29.95
67, 72, 77mm	$46.95	$39.95
82mm	$49.95	

Hypered 2415 film, 36 exp ...$9.95 ...3/$27

TELE VUE™ EYEPIECES USE THE BEST!!

Note: Prices increase $10-$20 on 1/1/84

Plossl, Wide-Field, Nagler Eyepieces
Tele Vue Plossl eyepieces have a sharp 50° apparent field-of-view. The Wide-Field eyepieces have a 65° field-of-view and are sharper than Erfle and Konig Eyepieces. The revolutionary Nagler eyepieces are sharp clear to the edge of a giant 82° field-of-view. **The eyepiece is half the telescope — use the best!**

7.4, 10.4, 13, 17, 21, 26mm Plossl $55
2½X **Tele Vue Barlow** Lens $55
32mm Plossl, widest true field in 1¼" ..$70
55mm 2" Plossl, widest possible field .$150
19mm Wide-Field, 1¼" eyepiece $100
24mm Wide-Field, "superb" $115
32mm Wide-Field, 2" eyepiece $185
40mm Wide-Field, "awesome" $240
4.8mm Nagler, 82° field $125
9mm Nagler, 82° field, "the best" $175
13mm Nagler, 82° field, 1¼" or 2" $200

SUPER-FINDER™

The LUMICON SUPER-FINDER is both a compact Rich-Field Telescope and a magnificent "Super-Finder". It has a fully coated 80mm achromatic lens and 300mm focal length. The Deluxe SUPER-FINDER has a superb 500mm f/6 air-spaced lens.

10X80mm SUPER-FINDER, with 30mm 1¼" eyepiece $149.95
SUPER-FINDER w/o eyepiece $129.50
IMPORTANT: Select 1¼" or 2" straight-through or right-angle viewing. Right-angle version requires a star diagonal.
DELUXE SUPER-FINDER w/o eyepiece (requires 1¼" or 2" star diagonal) $199.50
1¼" star diagonal, 30mm aperture ..$26.95
2" LUMICON mirror-type star diagonal, threaded for 48mm filters .....add $89.50
Mounting rings, 3-5/8" I.D $16.95/pair
Mounting adapter for C-8, Meade etc ...$35

NEW! SUPER C-8, FLUORITE C70 by CELESTRON

HIGH PERFORMANCE 8" TELESCOPE SYSTEM (Black Super C-8 Shown) ...$1250
Includes your choice of a black or orange Celestron **Super C-8** 8" f/10 complete telescope system.
List price value = **$1620.** Includes a high precision 7" diameter Byers worm gear drive system ideal for astrophotography (10 arc second periodic error), high transmission coatings, 8X50mm right-angle finderscope, equatorial wedge, heavy-duty Meade adjustable field tripod, accessory tray, dew shield, no-tool knob set deluxe latitude adjuster, 26mm (77x) multicoated Plossl 1¼" eyepiece, 7mm (286X) orthoscopic eyepiece, padded carrying case, all standard accessories, star map and finder cards for all the messier objects. Shipping added ($30-$40) for charge orders.

OPTIONS BOOST PERFORMANCE
Starbright enhanced silver coatings boost visual transmission 10-15% (C-8 only) ..$98
LUMICON® Premium UHC Filter ..add $79
LUMICON® Cassegrain EASY-GUIDER and Rich-Field Viewer ($216 value) ....add $198
LUMICON Rich-Field Viewer, 2" aperture ...$99
Deluxe Piggyback Mount, adjustable $39.50
LUMICON Deluxe Rich-Field Viewer system w/ 32mm Tele Vue Plossl, 1.5° true field$169
200mm f/3.5 superb multicoated lens $99.50
Electric Declination for C-8 .....$75
Dual Axis Drive Corrector for astrophotography with electric declination $248

Celestron C-70 fluorite refractor with equatorial mount $998
Fluorite objective lenses deliver amazingly sharp and high contrast images with essentially zero color distortion. **Refractor Tube Assemblies** include a 26mm Plossl 1¼" eyepiece, 1¼" star diagonal, rack & pinion focuser, dew cap and 6X30mm finderscope. **Refractor Equatorial Mounts** include adjustable wood tripod, setting circles, slow motion controls, azimuth and altitude fine adjustments, accessory tray, counterweight, and mounting rings. Optional electric drive motor is highly recommended.
C70, 70mm f/8 fluorite refractor ($800 list) .**$695**
C80F, 80mm f/8 fluorite refractor ($900 list)**$845**
Mounting rings (specify for C70, C80F) **$45**
Refractor equatorial mount, ($400 list) ...**$335**
C80, 80mm f/11.4 refractor & mount complete telescope system ($725 list) **$568**
C70 fluorite refractor & equatorial mount, complete telescope system ($1200 list) **$998**
C80F fluorite refractor & equatorial mount complete telescope system ($1300 list) ...**$1150**
Electric drive motor & quartz drive corrector ($125 list) **$110**
LUMICON EASY-GUIDER for photography .....add $129

DEEP-SKY ASTROPHOTOGRAPHY

FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.
†Patent Pending

MODEL 100 HYPER-KIT for 35mm film, rolled-up. *Takes longer,* but it easy to use. Not recommended for 2415 .....$225.00

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds $275.00

MODEL 600 HYPER-KIT [See Photo] Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates $299.50

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ...$525.00

Temperature controller for any HYPER-KIT $59.50

Electric Vacuum Pump $265.00

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X ealser guide-star selection, use 48mm filters, 360° camera rotation, large prisms fo bright guide-starts. *Specify Camera and Telescope type.*

†Patent Pending

NEWTONIAN EASY-GUIDER™

Full aperature. Installs in secs. Specify 2" or 1¼".
NEWTONIAN EASY-GUIDER $139.50
3X Relay Diagonal [See Photo] $59.50
Illuminated reticle eyepiece system .$59.50

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation-3X shorter exposures! **Superb rich field viewing, too!**
CASSEGRAIN EASY-GUIDER $199.50

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**
GIANT EASY-GUIDER $359.50
48mm DEEP-SKY Filter ordered with any EASY-GUIDER [SAVE $20] .....add $79.95

WHAT DO YOU NEED?

1. Hypersensitized Film. Use a LUMICON HYPER-KIT to insure a fresh supply, or use film pre-sensitized by LUMICON.
2. LED Illuminated reticle eyepiece system and battery pack, dual crosslines ...$59.50
3. Telescope with good drive. (See above)
4. Piggyback adapter (state telescope type)...$25 Deluxe adjustable $39.50
200mm f/3.5 multicoated lens.....$99.95
5. Filtration is essential for all lenses. Use hypered 2415 and the H-Alpha Pass Filter. For III a-J or color, use the Minus Violet Filter or the LUMICON DEEP-SKY Filter.
6. Off-axis guider is **essential** for consistantly good prime-focus astrophotography.
7. Dual-axis drive corrector and electric declination (state telescope type).....$259

HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. For fine grain B&W film use 2415. The fastest color films are Fujichrome 400 for slides and Kodak VR1000 for prints. Use VR1000 for galaxies and Fujichrome 400 for nebulae.

Film Type (35mm unless marked)	Exposures	Price
2415, Ultra-fine B&W, red sens	36	$9.95
Ektachrome 200 prof. 5036	20	$9.95
Fujichrome 400, "Excellent"	20	$12.95
VR1000, fastest of all, color negs	12	$12.95
5072, color slides from negs	36	$6.95
D-19 B&W Developer, 1 gal.		$5.95

LUMICON®

2111 Research Drive #5D, Livermore, CA 94550
For phone orders please call (415) 447-9570
LUMICON Products catalogue $2
Foreign orders add $8 ($20 for HYPER-KITS).
California Residents add 6% tax.
Prices subject to change w/o notice.

DSM Reports

Of Stellafane, Optics, and the Art of Deep Sky Observing

What is it that makes a faint deep sky object visible in one telescope but not in another — or more puzzlingly, make it more easily seen in one telescope than in another of the same aperture? It's a question I've been pondering because, among other things, I am now the owner of a home-built refracting telescope and I've observed some things that I didn't quite understand at first. Stellafane figures in the title of this story primarily because it's at Stellafane that I've had hands-on observing with some pretty unique telescopes, and those observations set me thinking.

Let me begin by posing a key question for deep sky observers: what makes observing "faint fuzzies" so intensely satisfying? Everybody has his own answers, of course. But again and again in conversations with many observers over the years, and enshrined in the pages of this magazine, whenever I've heard praise of deep sky observing, it's been phrased in such terms as "velvety-black sky," "tiny pinpoint stars," "delicate spiral arms," and "like floating in space." Translated into optical terms, what I think they're saying is that a telescope that's desirable for deep sky observing must have low internal scattering, excellent optics, high image contrast, and a wide field of view. Those are the elements of telescope performance that observers apparently value most when they recollect their most satisfying views of the sky.

Now let me get to the point of this article with the all-important corollary question: What kind(s) of telescope provide this performance? Knowing amateur astronomers, opinion is certain to be divided, so let me make my disclaimer at the outset. I am not talking about "does it work?" performance; instead I am talking about subtle features that make a telescope a pleasure to use, features that delight because the telescope delivers rather more than you thought it could. In my opinion, the scales are heavily loaded in favor of refractors — but, providing they're designed with care, Newtonian reflectors can reclaim much of that lost ground.

Three years ago I wasn't so sanguine about refractors, but as I traveled to recent astronomical meetings — especially Stellafane — I kept seeing refractors. Clearly refractors were enjoying some sort of comeback. I tried them, liked them, and began to wonder if there wasn't something to all that turn-of-the-century stuff about the superiority of refractors. But what really got me thinking and observing was a rather complex mischance: two unmounted pieces of glass reputed to be a refractor objective. I got them some ten years ago when a small company I worked for went out of business. They couldn't meet payroll and said, "Here, take this lens in lieu of your pay." So I did. The glass sat in a box until last year when I built a telescope around it, a great big 8-foot long, 6-inch f/15 refractor.

I've used it a fair amount from my urban back yard and have lugged it off to dark skies enough times to have a good idea of how well it performs. And what I see is low internal scattering, excellent optics, high image contrast, and (when used with a 32mm Konig or 55mm Plossl eyepiece) a wide field of view. The stars are crisp and sharp to the edges of the field, and faint nebular objects look fine in it. I've found it's as good for tracing the feathery arcs of the Cygnus Loop as it is for splitting less-than-one-arcsecond double stars.

But I've seen comparable or better performance from other 6-inch telescopes at Stellafane. One was Roland Christen's apochromatic refractor, a 6-inch f/11 triplet he brought to Stellafane in 1981. It had virtually no secondary spectrum. This year, he had a Jaegers lens with a third element located halfway down the tube which made that instrument nearly color-free, but unfortunately I did not have the opportunity to test it.

Another impressive performer was Mike Mattei's 6-inch f/15 Schupmann telescope, shown this year at Stellafane. Schupmann refractors also have negligible secondary spectrum when they're properly tuned up. I compared that instrument quite carefully with my achromatic refractor, unfortunately under mediocre seeing conditions. It's impressive.

Of course, when it comes to aperture per dollar, refractors lose — and lose big. But on an inch-for-inch basis of comparison, they're extremely impressive performers.

So what is it that refractors have which reflectors don't? The most important difference for deep sky work is that refractors have baffled tubes which result in low internal scattering. If you look down the focuser of any reasonably well-made refractor, you'll see nothing except the objective lens and a few dull glints off baffles. The general impression is that of an inky darkness inside the tube. When you look into a reflector, chances are that you'll see the diagonal holder, the inside of the tube directly, rather bright low-angle reflections off the tube wall reflected in the mirror, dust specks on the diagonal, and as often as not, the ground seen through openings around the mirror cell. Holy cow — it's as bright as day in there and a lot of that light reaches your eye! So much for low-contrast in reflectors. In a refractor, stray

Richard Berry and 6-inch Dobsonian refractor.

light generally requires two scatterings to reach the eye; in a reflector, just one.

By the way, I want to credit Mike Simmons, who spoke this year at Stellafane, for his formulation of some of these ideas. Mike is an optical designer; his interests run to apochromatic refractors, among other things. We have clearly been thinking along similar lines. Anyhow...

Refractors also generally have excellent optics. Not only are the objectives well corrected, but the long focal ratio means that eyepieces used with them perform well. Reflectors can have excellent optics, but remember that for pleasingly tiny star images, good eyepiece performance is also crucial. In the last few decades, the focal ratio of reflectors has steadily dropped. Nowadays f/4.5 is not an uncommon focal ratio to find in the hands of a deep-sky observer, but asking eyepieces to handle that fast light cone is asking a lot — and you know how often you see bird-shaped star images at the edge of the field.

Refractors stay in collimation. Fast reflectors are are pain to collimate and keep collimated because the coma-free field is so small. Refractors, at least those with Fraunhofer objectives, have a large field so if they do drift out of collimation, the image quality remains good. The mirrors in most reflectors bounce around a lot because we're afraid to warp them if we grip them tightly. (This can be fixed, by the way — use aquarium cement to keep mirrors in place. It's soft and it sticks reliably. The little 6-inch f/8 Newtonian I showed this year at Stellafane has its mirror bonded to the mirror cell with aquarium cement, and it maintained collimation throughout the 2,500 mile road trip to Stellafane and back.)

But focal ratio and collimation are only part of "excellent optics." The four optical surfaces of an achromat are spherical and can be made with little local figuring. Figuring is necessary to

The DSM crew at Stellafane 1983: (from left to right) David Levy, Phil Harrington (back), Walter Scott Houston (front), Jim Meketa, Glenn Chaple, and Richard Berry.

deform an optical surface away from a sphere, but by its very nature, figuring tends to leave zones, ripples, lumps, and "texture" on the glass surface. Even if these errors are small, they scatter light over large angles, resulting in low image contrast. (If there are 100 ripples across the diameter of a mirror, they scatter light over a region 100 times the diameter of the Airy disk. The smallest ripples are the biggest scatterers.) The spherical optics of an achromat are smooth, so the Airy disk and rings look like they should. They seldom do in reflectors — often the Airy disk is surrounded by figuring "noise," not diffraction rings. (The same is often true of Schmidt-Cassegrain telescopes.) Long focus Newtonians typically give better images than short focus ones because less figuring goes into shaping the mirror surface. That's a clue to getting better reflector performance.

Finally, vis-a-vis the last of our deep sky performance desiderata, it's easier to get good images with a wide angle eyepiece at long focal ratios, so things are loaded in favor of refractors there, too.

One thing I should add for those who don't yet know it: a long focal ratio does not mean that the image will be dim. You must, of course, use an appropriately long-focus eyepiece to produce low magnification and you'll get a large exit pupil with the long focal ratio. Six-inch f/5 and f/15 telescopes, equipped with 20mm and 60mm eyepieces, respectively, will have the same magnification, the same exit pupil, the same image brightness. But given equally good eyepieces, there is every reason to expect the f/15 instrument to yield better star images and better image contrast.

My achromat, Christen's apochromat, and Mattei's Schupmann all perform well above the normal standard for 6-inch telescopes. All three display crisp star images. Of course, the achromat suffers from secondary color — around Vega you see a blue-violet halo well over 30 arcseconds across. On fainter stars, the achromat's secondary spectrum becomes invisible, and the stellar images appear textbook perfect, but that purple halo remains a problem for planetary viewing. The out-of-focus purple light is still there when you're doing deep sky work but probably doesn't matter because your eye is rather insensitive to those wavelengths.

From what I saw of it, I would guess that Mattei's Schupmann had a small amount of ripple, but that's understandable because it has such a large number of optical surfaces in it. It also needed constant tweaking lest the image become either astigmatic or spread into a vividly colored spectrum. That instrument was a prototype, though, so some allowance must be made. Its freedom from color error should make it an extraordinary planetary telescope; for deep-sky observer the greatest drawback of the Schupmann telescope is its small field of view.

One of Christen's triplets, when I saw it at Stellafane in 1982, had just a trace of color when tested on Vega — but it delivered, without a doubt, the best star images I've ever seen. However, as an old reflector builder, I'm loathe to let refractors win all the prizes. For one thing, you can't buy a refractor that'll beat a reflector's light-gathering ability for the same number of dollars. But there are exceptional performers among the reflectors.

At AstroFest 1981, for example, I spent about half an hour on a night of fine seeing, viewing through A. L. Wood's 6-inch f/14.7 tri-schiefspiegler. The system is superbly baffled like a refractor, and the mirrors all had long radii and smooth optical surfaces. There was a big surplus Erfle eyepiece mounted on it. It split Epsilon Lyrae beautifully, but the memory of the Andromeda Galaxy seen through that instument is what has stayed with me. The sky was velvet black, the stars tiny pinpoints, and the galaxy's dark lanes stood out clearly. Yet schiefspeiglers aren't usually considered deep-sky instruments.

At Stellafane 1982, I saw another outstanding reflector. Built by Gregory Reeve, it was a 6-inch f/11.3 reflector with a secondary mirror only ¾" across and mounted on an optical window. Reeve gave a talk about optimizing reflectors. He recommended a smooth, long-focus primary mirror, small obstruction, short focuser (to keep the secondary small), sealed tube — all the usual stuff — but also an extended tube, velvet and black painted mosquito netting tube liners (for low reflectivity), and enhanced coatings. His telescope gave refractor-like performance. I tested it on Vega and Epsilon Lyrae (what else?); its biggest drawback was that it was on a pipe mounting so shaky that it was difficult to find anything, let alone do a critical evaluation of image quality. Nonetheless, I persevered, and saw just about perfect performance in a reflector. So carefully-made reflectors can give refractors a run for the money. Both Woods and Reeve certainly came close.

Most reflectors suffer because they get dirty easily and dirty mirror surfaces scatter light. That zaps contrast. Mirrors, even good ones, tend to have their worst defects at the edge — so eliminating the outermost ⅛" or so sometimes often helps a lot. Lenses are edge-supported so the last little bit is usually masked off. That helps image quality. And fast mirrors tend to be zoney, especially fast mirrors made by overambitious mirror makers. Zap-zap to image quality. Finally, in the earnest attempt to keep the tube short, sometimes the diagonal is right at the end of the tube and skylight simply floods into the field. Zap-zap-zap to contrast!

To sum up: what telescopes will give stunning performance on deep sky objects? On the basis of my own experience and the passed-along expertise of Mike Simmons and Gregory Reeve, I suggest that you incorporate as many as you can of the following characteristics in your next telescope, whether refractor or reflector: long focal ratio, good-quality eyepieces, a closed tube (meaning a window for reflectors), clean optics, scratch- and scuff-free optics, the tube extending two diameters beyond the objective or diagonal, enhanced (or anti-reflection) coatings, a sharp aperture stop, smooth optical figure, a baffled tube bottom (on reflectors), a black tube interior, and roughened tube wall and/or efficient baffling. *Richard Berry.*

R.V.R. OPTICAL

The instruments shown in this ad represent only a small fraction of the vast selection of astronomical telescopes and binoculars available thru R.V.R. Optical.

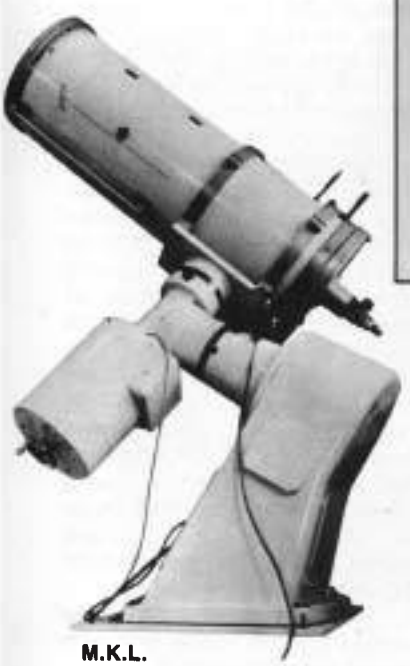
We cater to the professional and amateur alike and because of this, we feel certain that we have just what you're looking for. If you are considering the purchase of a telescope or binocular, give us a call or send for our large array of illustrated literature — $3.00 U.S.A. $6.00 Foreign. Also specializing in Foreign Orders — Phone 7 Days a Week.

R.V.R. Exclusives:

1. **SUPER GIANT 25x150mm *RIGHT ANGLE* ASTRO BINOCULARS.**
2. **M.K.L. 16.9″ MODIFIED NEWTONIAN CASSEGRAIN.**
3. **GIANT METEORITES AVAILABLE (MUSEUM QUALITY).**

For Sale: Questar 12″, 1 Year Old, Fully Equipped and in mint condition. Inquire for further details.

MEADE



M.K.L.

M.K.L.

CELESTRON

(914) 337-4085

P.O. BOX 62
EASTCHESTER, N.Y. 10709

Scanning the Literature

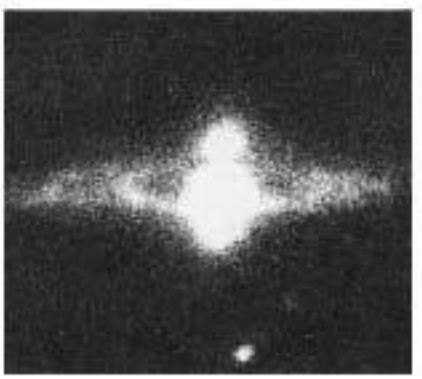
Several types of observations in the last decade have suggested a difference in the chemical and dynamical histories of halo stars in elliptical galaxies and their attendant systems of globular clusters. In particular, the globulars may form before the proto-galaxy organizes itself. One concurrent problem has been finding a source for elements heavier than hydrogen and helium (presumably the only components of the primordial ooze) that we observe in field stars of galaxies. In "Globular Clusters and the Early Chemical History of Galactic Halos," D.S. deYoung, Kevin Lind, and S.E. Strom (*PASP* **95**:401 July) present calculations showing that mass-loss from stars in globulars could play a significant role in the enrichment of heavy elements ("metals") in galactic halos.

The most massive stars in these clusters evolved very quickly upon formation, and by now have completely dissipated, leaving only the low-mass stars we see in globulars today. During their lives, these stars generated metals via nucleosynthesis, and at various stages ejected material into space. The authors show that if globular clusters formed first, enough metal-enriched mass could have been thrown off by these massive stars to produce the observed metal abundance in field stars which formed out of the protogalactic medium. Noting that "a unique picture of globular cluster formation is not at hand," the authors emphasize that this is not the only possible mechanism for metal enrichment, merely that it is physically reasonable within the limits of current models. The complete scenario is doubtless more complex, involving many other factors.

As if to provide comparison with this article, a color-magnitude diagram for a nearby galaxy is given in "Stellar Populations in Local Group Dwarf Elliptical Galaxies. I. NGC 147" by J.R. Mould, Jerome Kristian, and G.S. DaCosta (*ApJ* **270**: 471, July 15). The authors obtained VRI photometry for stars to I magnitude 23 in the outer regions of this galaxy in Cassiopeia, which is a member of the Andromeda system. Among their conclusions: the stellar content in the outer parts of NGC 147 resembles that of normal globular clusters in the Milky Way; the galaxy's stars form a short, broad giant branch, implying that there is some range in chemical composition in the stars, and that the stars are mostly older than 12 billion years.

A peculiar galaxy is the subject of a thorough study of Francois Schweizer, Bradley C. Whitmore, and Vera C. Rubin entitled "Colliding and Merging Galaxies. II. S0 Galaxies with Polar Rings" (*AJ* **88**:909 July). They give

Brad Whitmore/Carnegie



A0136-0801

photometric and spectroscopic velocity measurements arguing that the 16th magnitude galaxy AO136-0801 is a normal S0 object seen edge-on with a polar ring of gas, dust, and young stars. Velocities at various points along the spindle-shaped main body show that it is rotating rapidly along the major axis: one side is approaching us, the other receding, much as we expect for a spinning disk seen edge-on. Thus the "spindle" is not a cigar-shaped object, as might be easily imagined from a photograph. The material in the ring is

Palomar Observatory

Polar ring galaxy NGC 2685

orbiting the spindle at ever higher speeds from the center outward, implying that there is substantial dark mass in a spherical halo around the galaxy outside the visible ring. The gas and young hot stars in the ring cause it to appear relatively blue and exhibit emission lines of hydrogen and other volatile gases. The paper includes a list of 21 other such "gyroscope" galaxies, the brightest being NGC 2685 in Ursa Major. Photographs of nine of the galaxies are shown, including the study object.

Until recently the accepted distance to Messier 33, the Triangulum galaxy, was based on work done by Edwin Hubble about 50 years ago. By that time a relation for Cepheid variables had been established, which correlates the period of variation of these stars to their intrinsic brightness: longer period stars are systematically brighter than shorter-period stars. Hubble used this relation to estimate the distance to M33 by photographing the galaxy frequently and determining the periods of Cepheids he discovered (this is the fundamental observation, by the way, that proved galaxies are very distant objects located far beyond the Milky Way). Hubble's magnitude estimates were based on a set of standard stars near the galaxy we know now had a scale problem beyond magnitude sixteen, and which Hubble had extrapolated to calibrate his magnitude 19 to 20 variable star measures.

Allan Sandage has made new observations that put Hubble's data on the standard photoelectric B magnitude system, and the results are compiled in "On the Distance to M33 Determined From Magnitude Corrections to Hubble's Original Cepheid Photometry" (*AJ* **88**:1108 August). Hubble's magnitude scale turns out to be off by about 2.5 magnitudes among the faintest stars, so his photographic blue magnitude 20 is really about B

Dwarf galaxy NGC 147: a giant globular cluster.

Palomar Observatory

magnitude 22.5 (i.e., he was going much fainter than he thought!). Whereas Hubble placed M33 slightly closer than the Andromeda galaxy, the new distance — based on a very well calibrated period-luminosity relation for Cepheids — is 1.11 megaparsecs (3.6 million light-years), half again farther than M31, and more than four times the distance of Hubble's earliest estimate!

A very "sexy" topic in astronomy these days is the chemical composition of globular cluster stars. Not so long ago astronomers assumed that since the cluster stars all formed at the same time, they should all have the same composition. When sensitive electronic detectors were attached to newly constructed 4-meter-class telescopes in the Southern Hemisphere (where globulars are best observed from), astronomers discovered that the spectra of the brightest individual red giants in globulars show a considerable range in the percentage of metals within them. Besides spectra, another method of analyzing compositional variations among cluster stars is to measure the width of the main sequence, which in globulars is comprised of stars as faint or fainter than the Sun. Any large variations in composition are reflected in a range of B-V colors in stars of the same magnitude. "On the Intrinsic Width and Luminosity Function of the M92 Main Sequence" by Allan Sandage and Basil Katem (*AJ* **88**:1146 August) gives B-V photometric data for about

Kitt Peak

Sandage and Katem provide photometry for M92.

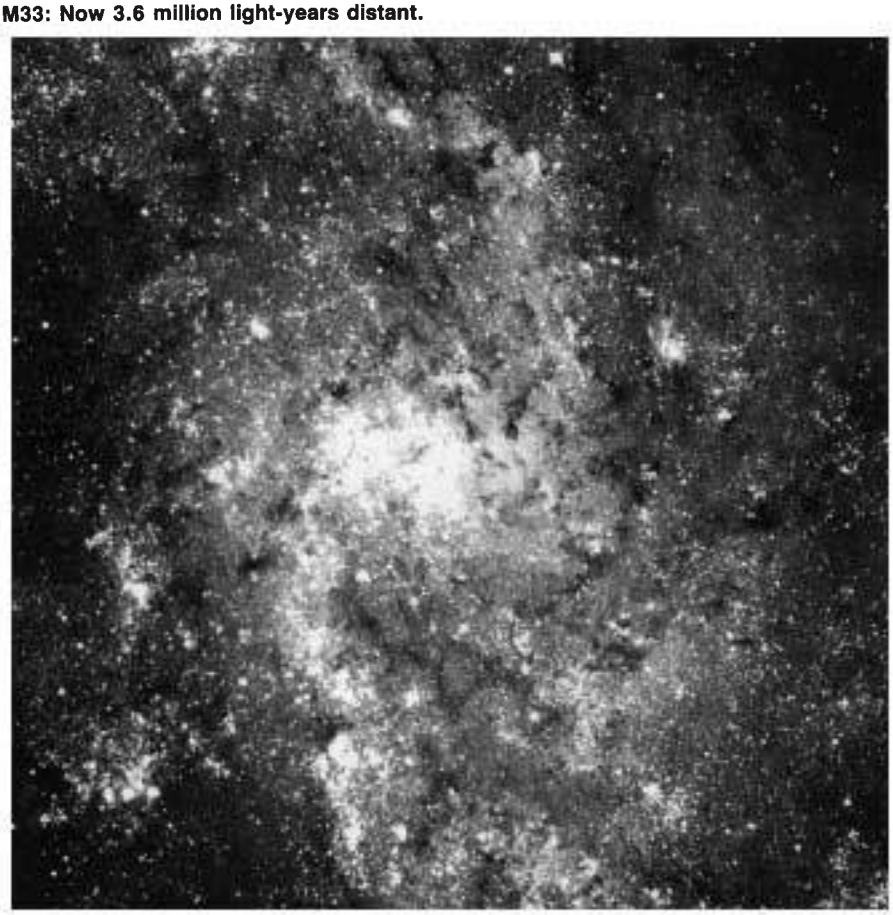
475 stars in the cluster fainter than V magnitude 18. The observed width of the main sequence, corrected for random errors in the photometry, is very small — possibly zero — with an upper limit of about 0.02 magnitude in B-V. Using the best current models of stellar evolution, this means that the cluster stars have practically the same composition, at least in terms of hydrogen and helium, but the method apparently is not sensitive enough to show variations in metal abundance among the stars. The problem remains then: what is causing the abundance variations in stars on the giant branch?

Based on this data and previously published results, Sandage (a busy man!) compares observations and theory in "On the Age of M92 and M15" (*AJ* **88**:1159 August). Recently derived theoretical color-magnitude diagrams are fit to the observed data to ascertain the ages of the clusters. In both cases the data are best represented by a "theoretical" cluster with an age of 18 billion years.

A faint globular cluster near Lambda (λ) Sagittarii and Messier 22 is examined in "The Globular Cluster NGC 6638" by Gonzalo Alcaino and William Liller (*AJ* **88**:1166 August). BV photographic photometry is given for 219 stars as faint as magnitude 19. The brightest giant stars are V magnitude 15 — difficult to resolve in a 12½-inch — and the cluster lies about 8.7 kiloparsecs (28,000 light-years) from the Sun in the direction of the center of the Galaxy. The stars are identified on photographs showing the field around the cluster as well as details in the core. Alcaino and Liller present data for M22 itself in "The Main Sequence of the Globular Cluster M22" (*AJ* **88**:1330 September). Again BV photometry of stars to about mag. 19 is given, but the brightest stars in this cluster are V magnitude 10.5. Several very nice photographs accompany the article.

An unusual binary star is the subject of "The WN4.5 Component of HD219460 in the Open Cluster Markarian 50" by David G. Turner, A.F.J. Moffat, R. Lamontagne, and H.M. Maitzen (*AJ* **88**:1199 August). New UBV photometry and new and old spectral types are thoroughly analyzed to determine the basic parameters of this cluster in Cepheus. The authors find the distance to be 3550 parsecs (11,600 light-years) and its age a young seven million years. The cluster is dominated by a tenth magnitude bright giant of spectral type B1, with an absolute magnitude of about −5. The star forms a close pair with a similarly luminous Wolf-Rayet star which shows broad emission lines in its spectrum.

M33: Now 3.6 million light-years distant.



Lick Observatory

Brian Skiff
421 West Aspen
Flagstaff, AZ 86001

C.O.D. & CHARGE CARDS

TO ORDER, CALL TOLL FREE

800-521-2828

IF BUSY, CALL (313) 665-3575

MONDAY THRU SATURDAY
9:30 TO 4:00 E.S.T.

FREE CATALOGUE (via 3rd Class)

Authorized **Meade** Dealer for 4, 8, and 10 inch Schmidt-Cassegrains

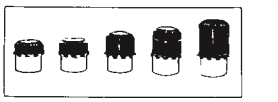
For First Class Delivery Remit $1.00
Air Mail Outside North America $3.00

HOW TO ORDER

MAIL ORDER: No special order forms required. Simply write a letter with your requirements. Payment via VISA, MASTER CARD, personal check or money order. Do not send cash. No minimum order.

FOREIGN ORDERS: We now specialize in fast service to any place in the world. Requests for pro-forma invoices welcome. We will tell you exact postal charges and other particulars.

Plössls by University



Plössl Eyepieces — You don't have to pay high prices to enjoy the high level of performance offered by these 4-element 1¼" O.D. Plössl eyepieces. All are parfocal (except the large 40mm unit), all are multi-coated, and all are threaded for filters. Our exclusive adjustable parfocalization ring lets you precisely fine tune the focal point of each eyepiece.
6mm, 9mm, 12.5mm, 18mm, 25mm, 40mm ..... **$45.00 ea ppd.**

Königs by University

The remarkable wide-angle König leads the field in high-performance!

König Eyepieces — With their wide angle and pinpoint definition, these truly are the "king" of wide field eyepieces. The perfect match for all those large Dobsonians now available. All are multi-coated and threaded for our special wide-aperature photo-visual filters. 1¼" O.D.
8mm, 12mm, 16mm or 24mm .. **$39.95 ea ppd.**
32mm ..... **$49.95 ppd.**

Binocular Viewer

Binocular Viewer — All the advanced features you have always wanted in a binocular viewer are incorporated in this beautiful instrument. 45 degree viewing angle. 360 degree rotation with thumb screw lock. Lockable interocular distance. Individual diopter adjustment. Removable 2X Barlow lens doubles your magnification. Uses 1¼" eyepieces and fits any 1¼" focusing mount. For refractors, reflectors, and catadioptric telescopes ..... **$279.95 ppd.**

2" O.D. Eyepieces

2" O.D. Eyepieces — We carry one of the finest selections of 2" O.D. eyepieces in the country. Chrome plated brass barrels threaded for filters.
18mm Orthoscopic — 4-element. Fully coated **$59.95 ppd.**
25mm Orthoscopic — 4 element, multi-coated **$63.95 ppd.**
40mm Orthoscopic — 4-element, multi-coated **$79.95 ppd.**
32mm König — Multi-coated, wide-angle design. 4-element ..... **$84.95 ppd.**
32mm Erfle Multi-coated, 5-element design Wide-angle ..... **$69.95 ppd.**
55mm Plössl — Multi-coated, 4-element design **$79.50 ppd.**
60mm Kellner — Fully-coated, 3-element design **$59.95 ppd.**
70mm Kellner — Multi-coated, 3-element **$64.95 ppd.**

Illuminated Reticle

Illuminated Reticle — This 12.5mm orthoscopic eyepiece is designed to meet the special needs of the astrophotographer. Enjoy the flat, highly corrected image only a true 4-element orthoscopic design can offer. Two-color. Flip a switch for amber or special night vision green. Focusable, micro-fine etched glass cross wires. Threaded for filters. 1¼" O.D. ..... **$46.95 ppd.**

Zoom Orthoscopic

Zoom Orthoscopic — This is the same fine quality continuous variable zoom we have sold for many years. Coated lenses with precision 7-element optical system. Takes the place of several individual eyepieces. 8.4 to 21mm focal length. **$54.95 ppd.**

Accessories for Celestron

Camera quality visual and photographic accessories for your Celestron and Meade Series 1000 and 2000 telescope.
T-Adapter ..... **$15.95 ppd.**
Tele-Extender .. **$15.95 ppd.**
Telecompressor (f/5) Includes extender tube for use with off-axis guider .... **$40.95 ppd.**
Telecompressor (f/5) large 50 mm) ..... **$75.95 ppd.**
Deep-sky f/5 visual adapter — Includes telecompressor lens, special T-Adapter, threaded ring, and wide aperture diagonal prism. **$75.95 ppd.**
Off axis guider body with 12.5mm orthoscopic illuminated reticle eyepiece ..... **$85.95 ppd.**
Off-axis guider body only ..... **$39.95 ppd.**
Exposure Dial — Gives correct exposure for moon phases, major planets, and deep space. 8 color and black-and-white films. Over 430 combinations ..... **$8.95 ppd.**
Celestron Meets the Home Video Recorder
Our popular book that tells you how to connect your Celestron or Meade Schmidt-Cassegrain to video cameras. ..... **$6.95 ppd.**
Erecting Prism — Fully coated Porro prism. 1¼" O.D. ..... **$28.95 ppd.**
Dakin 2.4X Barlow — The original high performance Barlow for telescopes. Large aperture 2-element fully coated lens. 1¼" O.D. Made in U.S.A. ..... **$59.95 ppd.**

New Items

20mm & 32mm R.F.T. ERFLE—These new multi-coated 1¼" O.D. Erfles have been designed to give excellent results with the popular short focal length Dobsonian systems.
32mm R.F.T. Erfle ..... **$65.95 ppd.**
20mm R.F.T. Erfle ..... **$45.00 ppd.**

2" O.D. BARLOW—A giant achromatic Barlow for those big telescopes! 40mm clear aperture. 2 power. Takes all 2" O.D. eyepieces .. **$55.95 ppd.**

Multiple Eyepiece Holder—Holds four of your favorite eyepieces. Click stops. Fits Celestron, Meade, and Dynamax Schmidt-Cassegrains . **$65.95 ppd.**

1¼" O.D. BARLOW—The finest 2 power Barlow we have ever made! Full 27mm aperture. Parfocalized with our Plössls. Fully coated. ..... **$32.95 ppd.**

Filters Filters

Color Filters — For photo-visual use: Color dyed optical glass, 1¼" machined metal cells may be piggybacked. Anti-reflection coated. Fit our Plössl and König eyepieces. **#12 Yellow, #21 Orange, #25A Red, #11 Yellow-Green, #58 Green, #80A Blue, #2 U.V., 20% N.D.** .. **ea. $6.95 ppd.**
Filter Adapter (for Celestron and Meade eyepieces) .. **$5.00 ppd.**

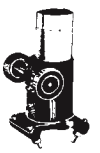
DayStar 300 — The original 3-channel nebular filter designed for blocking mercury and sodium light pollution while still passing over 90% of the primary emission lines. Please state brand of 1¼" O.D. eyepieces to be used with ... **$60.00 ppd.**

University Mark 5 — One of Japan's top optical coating laboratories has come up with an advanced nebular filter for dealing with mercury and sodium light pollution. We are proud to be the first to offer this excellent quality, yet reasonably priced filter. Please state brand of 1¼" O.D. eyepieces to be used with ..... **$42.50 ppd.**

11 × 70 Viewfinder

11 x 70—Our largest and finest finder. Wide field 3-element Kellner eyepiece. Large 2-element 70mm objective. Right angle viewing prism. Oil smooth helical focusing.
All metal construction ..... **$89.95 ppd.**
Phosphorescent Crosshairs ..... **ADD $5.00 ppd.**
Dual Ring Mounts for above ..... **$14.95 ppd.**

Reflector Parts



Helical-Cut Rack and Pinions — Strong yet lightweight aluminum construction. Oil smooth focusing action with tension adjustment screws.

Vega 1 — Standard 1¼" eyepiece holder. Ample focusing travel for reflectors up to 12½" ..... **$22.95 ppd.**

Vega 2 — Our largest and best! Takes 2" O.D. eyepieces. 1¼" O.D. eyepiece holder included at no extra cost. 3" travel. The perfect eyepiece holder for those giant Dobsonian reflectors ..... **$42.95 ppd.**

Ring Mounts — Mounts large viewfinders and guide scopes to your telescope. Three adjusting screws and locking nuts per ring.
2⅝" I.D. ..... **$10.95 pair.**
3¼" I.D. ..... **$12.95 pair.**
5¼" I.D. ..... **$18.95 pair.**
7¼" I.D. ..... **$24.95 pair.**

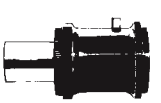
Mirror Cells — High quality aluminum mirror cells that adjust to fit your tube exactly. Easy collimation by means of spring-loaded screws. Mirror sizes listed below.
4¼" ..... **$12.50 ppd.**
6" ..... **$14.95 ppd.**
8" ..... **$16.95 ppd.**
10" ..... **$21.50 ppd.**
12½" ..... **$34.50 ppd.**
13.1" ..... **$54.95 ppd.**
14¼" ..... **$72.50 ppd.**
16" ..... **$92.50 ppd.**
17½" ..... **$125.50 ppd.**

4-Vane Spiders — Very nice quality secondary mirror holders. All are fully adjustable and vibration free. Specify tube O.D. when ordering.
1.30" ..... **$14.50 ppd.**
1.50" ..... **$15.50 ppd.**
1.83" ..... **$16.50 ppd.**
2.14" ..... **$18.50 ppd.**
2.60" ..... **$20.50 ppd.**

Books Books

Astronomical Formulae For Calculators. Revised Edition. By Jean Meeus. First printed in 1979, this book has met with world-wide acceptance. This book assumes that you know how to write your own programs if you have the formulae and some examples. For the programmable calculator, but many have found it helpful in writing programs for microcomputers. The forty chapters cover a wide range of subjects including: Julian Day and Calendar Date, Sidereal Time at Greenwich, Conjunction Between Two Planets, Elements of the Planetary Orbits, and Positions of the Satellites of Jupiter. Forward written by Roger W. Sinnott. An excellent addition to your astronomical library. **Price $14.95 ppd.**

Camera Adapter

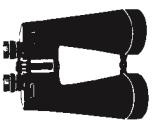


Professional Camera Adapter — Couples your camera to any 1¼" O.D. focuser. Excellent quality anodized aluminum. For first focus and eyepiece projection. Threaded for 27mm photographic filters. Standard T-thread. Use with camera T-ring listed below ..... **$17.95 ppd.**

T- Camera Rings

Camera T-Rings — Pentax K, Pentax S, Yashica, Canon, Minolta, Exakta, Konika, Olympus OM-1, OM-2 ..... **$9.95 ea ppd.**
T to C mount — Attaches TV cameras with "C" mounts to standard T-adaptors .... **$15.95 ppd.**

Deep-Sky Binoculars

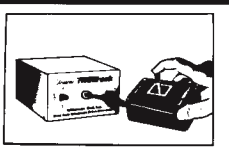


Deep-Sky Binoculars — Our popular 80mm binoculars now feature an improved, strong, one-piece construction. Easy to hand hold. UV coated objectives in addition to fully coated eyepieces and prisms. 5-element eyepieces on the 20X unit, 3-element on the 11X model. Center-focus design with a reinforcing bridge between the objectives. The 11X model offers higher relative light efficiency than smaller 70mm units. Certificate of collimation with every pair. Complete with straps, dust caps, and fine quality carrying case.
11x80 or 20x80 ..... **$179.95 ppd.**

Car Window Mount — Mount your large binoculars, spotting scopes, and cameras safely on your car window. Lockable pan head. All-metal construction ..... **$37.50 ppd.**

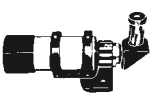
Binocluar Nebular Filters — Screw these high quality 3-channel nebular filters onto your large binoculars and cut down on sodium and mercury light pollution. **per pair** ..... **$69.95 ppd.**

Dual-Axis Drive Corrector



Drive Corrector — This is the AC/DC joystick control center Celestron and Meade 2080 owners have been waiting for! Linear output. Heavy-duty with plenty of power, yet draws less than ½ amp at 12 VDC. Our price includes, at no additional cost, a declination motor, drive belt with slip-clutch, and mounting bracket. Please indicate if for C-5, C-8, or Meade 2080 ..... **$187.00 ppd.**

8 × 50 Viewfinders



Enjoy brilliant images and a wide field of view. Available with unique 0.8 degree offset reticle for precise pole alignment. 4.8° actual field of view. Fully coated 6-element optical system. Oil smooth helical focusing. Tube is color matched to your Celestron, Odyssey, or Meade telescope. Fits in carrying case. Right-angle viewing prism. Includes metal mounting bracket.
Fits Celestron 8 (Cross Hair) ..... **$54.95 ppd.**
Fits Celestron 8 (True Polaris Finder Reticle) ..... **$57.95 ppd.**
Fits Meade 2080 (Cross Hair) ..... **$54.95 ppd.**
Fits Meade 2080 (True Polaris Finder Reticle) ..... **$57.95 ppd.**
Fits Odyssey (Cross Hair) ..... **$54.95 ppd.**
Fits Reflectors (White tube, no bracket) ..... **$51.95 ppd.**
Phosphorescent Reticle—Crosshairs glow in the dark. When ordering any of the above 8x50 finders **add $5.00.**
Straight-Through Adapter — Converts any of above 8x50 finders to straight-through viewing in seconds ..... **$13.95 ppd.**

Odyssey

Reach into the depths of the Universe with Odyssey Telescopes!

We are an authorized dealer for the Odyssey line of Dobsonian telescopes. These remarkable instruments bring you true visual equalization while viewing the Universe. We now offer many unique accessories designed for the Odyssey line including setting circles, viewfinders, and eyepieces. Call us on our **toll free Odyssey owner's hot line (800-521-2828)** for the latest list of new accessories!

UNIVERSITY OPTICS
P. O. Box 1205 2122 E. Delhi Rd.
Ann Arbor, Michigan 48106

Money-back guarantee on all items.
We are now completing our second decade of service to astronomers.

SARNA DEEP-SKY ATLAS

The next best thing to an experienced observer to help you find and identify deep-sky objects. Includes all 109 Messier and 145 other interesting nearby objects for a total of 115 galaxies, 41 globular clusters, 25 planetary nebulae, 56 open clusters and 17 diffuse nebulae. All are identified by NGC and Messier numbers. This large-scale atlas is a new approach to observing deep sky objects. Unlike most guides which locate objects in R.A. and Dec., simple, easy to follow directions are provided for aiming a telescope at the exact area of the sky, and using bright, easily located stars shown on monthly star maps such as in this magazine. Each chart is an accurate, closeup star map of the area around each object, but with the confusing clutter of faint stars removed. You will be able to match the chart's star pattern with what you actually see in your telescope's eyepiece. Thomas Sarna, professional draftsman and avid observer has worked four years to produce this atlas. Each of the 102 charts is printed with a dark blue background and white star fields on heavy 8½" by 11" card stock. Reference data is recorded across the top of each chart. Astrophotographers will find the Sarna Deep Sky Atlas particularly helpful since it shows nearby guide stars and even allows the centering of objects too dim to be seen with the eye.

☐ **Sarna Deep Sky Atlas** $30.00

— MATHEMATICAL & POSITIONAL ASTRONOMY —

- ☐ **Software for Photometric Astronomy** Ghedini .. 26.95
- ☐ **Celestial Basic** 14.95
- ☐ **Mathematical Cosmology** Landsberg/Evans 17.95
- ☐ **Spherical & Pract Astro as Applied to Geodesy** Mueller 40.00
- ☐ **Fund. Formulas of Physics** Menzel 14.00
- ☐ **Princ. Perturbations in Solar System** Airy 5.95
- ☐ **Astro. Formulae for Calculators** Meeus 2nd ed.. 14.95
- ☐ **Practical Astronomy With Your Calculator** 2nd Ed. Duffett-Smith 9.95
- ☐ **Algorithms for RPN Calc.** Ball 29.95
- ☐ **Math. Astro. with a Pocket Calculator** Jones... 24.95
- ☐ **Astrophysical Formulae** Lang 53.00
- ☐ **Positional Astronomy and Astro-Navigation Made Easy** Mills 39.95
- ☐ **Fundamental Astrometry** Podobed 16.00
- ☐ **Textbook on Spherical Astro.** Smart 19.95
- ☐ **Princ. Astrometry** van de Kamp 24.50
- ☐ **Spherical Astro.** Woolard/Clemence 58.00
- ☐ **Astrophysical Quantities,** Allen 45.75
- ☐ **Computational Spherical Astro.** Taff 36.95
- ☐ **Calculator Calculus** McCarty 19.95

ALL PRICES SUBJECT TO CHANGE WITHOUT NOTICE.

Don't see what you need? For a large format 32 page catalog listing nearly 1500 books and other astronomy related items send:
☐ $1.00 for First Class postage in U.S.A.;
☐ $1.00 for Foreign Sea Mail; ☐ $5.00 for Foreign Air Mail.
We include a copy of our catalog with each order.
Foreign Customers – shipping charges extra; write for free Proforma Invoice detailing costs.

Charge My: ☐ VISA ☐ MasterCard
MC INTERBANK NO. | CARD EXPIRES MO. YR. 3/83
CHARGE CARD NUMBER
CARD HOLDER NAME (PLEASE PRINT!)
CARD HOLDER SIGNATURE
NAME
ADDRESS
CITY STATE ZIP

SUB TOTAL $ _____
HANDLING 1.00
VA: + 4% Tax _____
TOTAL $ _____

— ATLASES AND CATALOGUES —

- ☐ **Catalogue of Star Clusters & Assoc plus Suppl 1** 115.00
- ☐ **Sarna Deep Sky Atlas** 30.00
- ☐ **Atlas of Andromeda Galaxy** Hodge 50.00
- ☐ **Galaxies** Ferris 16.95
- ☐ **Small Magellanic Clouds** Hodge/Wright 55.00
- ☐ **Mag 6 Atlas** 12.95
- ☐ **Yale Bright Star Catalogue** Hoffleit 45.00
- ☐ **Atlas of Solar Spectra Between 1175 & 1950 Angstroms** Cohen 34.00
- ☐ **Rainbows, Halos & Glories** Greenler 27.50
- ☐ **AAVSO Variable Star Atlas** 49.95
- ☐ **Emission Line Survey of Milky Way** 17.00
- ☐ **System for Open Star Clusters & The Galaxy Atlas of Open Star Clusters** Alter 66.00
- ☐ **Atlas Borealis** 49.95
- ☐ **Atlas Eclipticalis** 49.95
- ☐ **Atlas Australis** 49.95
- ☐ **Ariz.-NASA Atlas of Infrared Solar Spectrum** .. 18.95
- ☐ **System of Lunar Craters** 4 vol + 4 lg mps 35.00
- ☐ **Atlas of Mars** NASA 15.00
- ☐ **Atlas of Mercury** NASA 21.00
- ☐ **A Master List of Non-Stellar Objects** 35.00
- ☐ **Rev. Shapley-Ames Cat. Bright Galaxies** Sandage/Tammann 30.00
- ☐ **Rand McNally New Concise Atlas of Universe** . 35.00
- ☐ **Index of Galaxy Spectra** Gisler/Friel 38.00
- ☐ **Hubble Atlas of Galaxies** 22.00
- ☐ **SAO Star Catalogue 4 vol** 60.00
- ☐ **Messier Album** Mallas/Kreimer 14.95
- ☐ **Rev. New Gen. Catalog of Non-Stellar Objects** 24.50
- ☐ **Sky Atlas 2000.0 Deluxe** Tirion 34.95
- ☐ **Field Edition** (unbound—white stars) 15.95
- ☐ **Desk Edition** (unbound—black stars) 15.95
- ☐ **Set of Desk & Field Editions** 26.95
- ☐ **Sky Catalogue 2000.0** Vol. 1 ..... 29.95
- ☐ **Rectified Lunar Atlas** Whitaker 35.00
- ☐ **Uppsala Gen. Catalogue of Galaxies** 89.95
- ☐ **Atlas-Rep. Stellar Spectra** Yamashita 79.95
- ☐ **Atlas—Spectra of Cooler Stars Types G,K,M,S, C** 10.00
- ☐ **Ref. Catalogue of Bright Galaxies** 35.00
- ☐ **2nd Ref. Cat. of Bright Galaxies** 56.00
- ☐ **Catalog of Galaxies and Clusters of Galaxies** Zwicky Vols 2 to 6 each 19.50
- ☐ **Whitney's Star Finder** 8.95

— HANDBOOKS —

Burnham's Celestial Handbook
- ☐ **Vol. 1,** Andromeda thru Cetus 8.95
- ☐ **Vol. 2,** Chamaeleon thru Orion 9.95
- ☐ **Vol. 3,** Pavo thru Vulpecula 9.95

- ☐ **Telescope Hdbk. & Star Atlas** Howard 21.95
- ☐ **Experiments in Astro.** Knox 4.95
- ☐ **Astro. with Binoculars** Muirden 13.95
- ☐ **Amateur Astronomers Hdbk** Muirden 3rd ed. ... 16.95
- ☐ **Astronomical Calendar 1983** Ottewell 10.00
- ☐ **Astronomical Companion** Ottewell 12.00
- **Amateur Astro Handbook** Sidgwick 4th ed.
- ☐ Hardbound 24.95
- ☐ Softbound 7.95
- ☐ **Proj & Demo in Astro.** Tattersfield 39.95

Webb Society Deep-Sky Observer's Handbook
- ☐ **Vol 1.** Double Stars 7.95
- ☐ **Vol 2.** Planetary & Gaseous Nebulae 9.95
- ☐ **Vol 3.** Open & Globular Clusters 13.95
- ☐ **Vol 4.** Galaxies 15.95
- ☐ **Vol 5.** Clusters of Galaxies 16.95

- ☐ **Observer's Handbook 1983** 7.00
- ☐ **Astronomy: A Handbook** Roth 24.95
- ☐ **Obs. Astro. for Amateurs** Sidgwick, 4th ed..... 5.95
- ☐ **Complete Manual of Amtr Astro.** Sherrod..... 10.95

— OPTICAL THEORY AND DESIGN —

- ☐ **Lens Design Fund.** Kingslake 30.00
- ☐ **Applied Optics,** Vol. 1. Levi 51.95
- ☐ **Applied Optics,** Vol. 2. Levi 95.95
- ☐ **Opt. Des/Ray-Tracing With Pkt Calc.** 7.50
- ☐ **Optics, A Short Course for Eng & Sci** 39.95
- ☐ **Elementary Wave Optics** Webb 25.00
- ☐ **Optics** Hecht/Zajac 28.95
- ☐ **Optical Aberr. Coef.** Buchdahl 5.00
- ☐ **Hndbk. of Optics** Opt. Soc. of Amer 75.95
- ☐ **Optical Prod. Technology** Horne 90.00
- ☐ **Optics** Sears 20.95
- ☐ **Modern Optical Engineering** Smith 47.50
- ☐ **Digital Image Processing** Pratt 52.50
- ☐ **Optical Physics** Lipson/Lipson 22.50
- ☐ **Aberr. of Symmet. Optical System** Welford 40.50
- ☐ **Concepts of Classic Optics** Strong 32.50
- ☐ **Modern Optics** Brown 32.50
- ☐ **Modern Geometric Optics** Herzberger 25.50
- ☐ **Current Trends in Optics** Arecchi 34.95

Applied Optics & Optical Engineering:
- ☐ **Vol. 1, Light** 72.00
- ☐ **Vol. 2, Detection of Light & Infrared Radiation** 72.00
- ☐ **Vol. 3, Optical Components** 72.00
- ☐ **Vol. 4, Optical Instruments, Pt 1** 72.00
- ☐ **Vol. 5, Optical Instruments, Pt 2** 72.00
- ☐ **Vol. 6, Coherent Optical Devices and Systems** 57.50
- ☐ **Vol. 7, Update** 49.50
- ☐ **Vol. 8, Update** 51.00

— PHOTOGRAPHY —

- ☐ **ExpoDial** for C-8 Meade 2080 Dynamax 8 ..... 8.95
- ☐ **LFK Astro. Exposure Guide** 4.50
- ☐ **Celestron Meets Home Video Recorder** 6.95
- ☐ **Skyshooting** Mayall/Mayall 5.00
- ☐ **Astrophotography Basics** Kodak 0.50

— REFERENCE —

- ☐ **Amer. Ephemeris (Astro. Almanac) 1983** 16.00
- ☐ **1983 Almanac for Computers** USN 8.50
- ☐ **Cambridge Encyclopaedia of Astro.** 40.00
- ☐ **Source Bk—Astro/Astrophysics** Lang/Gingerich 50.00
- ☐ **Astro. Data Book 2nd. Ed.** Robinson 24.95
- ☐ **Guinness Book of Astro Facts & Feats** Moore .. 17.95
- ☐ **Facts on File, Dict. of Astronomy** Illingworth ... 7.50
- ☐ **Time & Clocks for Space Age** 10.95
- ☐ **Observatories of the World** Marx 16.95
- ☐ **Concise Encyclopedia of Astronomy** Weigert... 24.50

— RADIO ASTRONOMY —

- ☐ **Radio Astro. for Amateurs** Heiserman 8.95
- ☐ **An Amat. Radio Telescope** 6.95
- ☐ **Messages from the Stars** Ridpath 10.95

— STARS AND GALAXIES —

- ☐ **Intro. Stellar Struc.** Chandrasekhar 7.00
- ☐ **Star Formation** Jong/Maeder 24.00
- ☐ **Language of the Stars** Kopal 28.95
- ☐ **Pulsating Stars** Kukarkin 65.95
- ☐ **The Big Bang** Silk 10.50
- ☐ **Astrophysics Gaseous Nebulae** Osterbrock 32.50
- ☐ **Dk. Nebulae-Globules-Protostars** Lynds 8.95
- ☐ **Stellar Atmospheres** Mihalas 35.95
- ☐ **The HR Diagram** Philip 36.85
- ☐ **Struc. & Evol. of Stars** Schwarzschild 5.00
- ☐ **Stars: Structure & Evolution** Tayler 12.00
- ☐ **Eclipsing Variable Stars** Tsesevich 49.95
- ☐ **Galaxy Formation** Gribbin 27.95
- ☐ **Globular Clusters** Hames/Madore 62.50
- ☐ **Evol. of Galaxies & Stellar Pop.** Tinsley/Larson 18.00
- ☐ **Exploring the Galaxies** Mitton 4.95
- ☐ **Celestial Masers** Cook 28.95
- ☐ **Stars and Star Systems** Westerlund 34.25
- ☐ **Late Stages of Stellar Evolution** Taylor 31.60
- ☐ **Var. Stars & Stellar Evol.** Sherwood/Plaut 73.70
- ☐ **Wolf-Rayet & High-Temp. Stars** Bappu/Sahade 31.60
- ☐ **BE and Shell Stars** Slettebak 60.55
- ☐ **Interacting Binary Stars** Sahade 30.00
- ☐ **Variable Stars** Strohmeier 45.00
- ☐ **Monsters in the Sky** Maffei 17.50
- ☐ **Language of the Stars** Kopal 28.95
- ☐ **Brightest Stars** DeJager/IAU 31.60
- ☐ **Double Stars** Heintz/IAU 16.00
- ☐ **Struc. & Evol. Normal Gal.** Fall/Lynden-Bell ... 29.95
- ☐ **Observ. Visual Double Stars** Couteau 19.95
- ☐ **Dark Matter in Open Clusters** Wallenguist 20.00
- ☐ **Searching Between the Stars** Spitzer 25.00

— SUN —

- ☐ **The Sun, Our Star** Noyes 20.00
- ☐ **Our Turbulent Sun** Frazier 16.95
- ☐ **Wooden Sundials** Stoneman 2.95
- ☐ **The Sun as a Star** Jordan 12.00
- ☐ **The Sun** Nicolson 16.95
- ☐ **Sunspots** Bray/Loughhead 7.00
- ☐ **Eclipse** Brewer 6.95
- ☐ **Sundials** Mayall/Mayall 12.95
- ☐ **High Energy Phenomena on the Sun** 9.00
- ☐ **New Sun, Solar Results from Skylab** 21.00
- ☐ **Quiet Sun** 14.00
- ☐ **Sundials** Waugh 3.50

— HISTORY —

- ☐ **Ancient Planetary Observations & the Validity of Ephemeris Time** Newton 35.00
- ☐ **Planet Saturn, History of Obs** 8.00
- ☐ **Star Names, Lore & Meaning** Allen 6.50
- ☐ **Discovery of Neptune** Grosser 3.50
- ☐ **History of Rocketry and Space Travel** VonBraun/Ordway 3rd Ed. 29.95
- ☐ **Starlight Nights** Peltier 8.95

— COMETS-METEORITES-BLACK HOLES —

- ☐ **Comets** Wilkening 29.95
- ☐ **Mod. Obs. Tech. for Comets** NASA 16.00
- ☐ **Motion, Evol. of Orbits & Origin of Comets** Chebotarev 63.20
- ☐ **Introduction to Comets** Brandt/Chapman 45.00
- ☐ **Gravity, Black Holes & the Universe** Nicolson .. 24.95
- ☐ **Meteorites & Their Origins** McCall 19.95
- ☐ **Nature and Origin of Meteorites** Sears 19.95
- ☐ **Meteorites** Dodd 69.50
- ☐ **Black Holes** Sullivan 17.95
- ☐ **Comets** Scientific American 7.95

— PHOTOMETRY —

- ☐ **Software for Photometric Astronomy** Ghedini .. 26.95
- ☐ **Photoelectric Photometry of Variable Stars** Hall/Genet 2nd ed. 17.95
- ☐ **UBVRIJKL Photometry of Bright Stars** 18.95
- ☐ **Photoelectric UBV Obs. of RR Lyrae Variable Stars** Johnson 4.50
- ☐ **Astronomical Photometry** Henden/Kaitchuck... 29.95
- ☐ **Cat. of Photoel. Mag & Colours of Visual Double & Multiple Systems** 30.00

— NEW SIDEREAL CLOCK —

Accurate to 1 Second in 650 Years*

Now an **assembled**, very **accurate** sidereal digital clock for a little more than the cost of 2 good eyepieces. Ideal for classroom, planetarium or observatory. Large 0.7" LED display can be easily read at 20 feet in classroom—farther at night in the dark. *Long term stability derives from the highly accurate 60 Hz frequency of the U.S. Power Grid.

- ☐ **Sidereal Clock with manual** $79.95
- ☐ **Matching Solar Clock with manual** 49.95
- ☐ **Matching Universal Clock with manual** 49.95

Willmann–Bell, Inc.

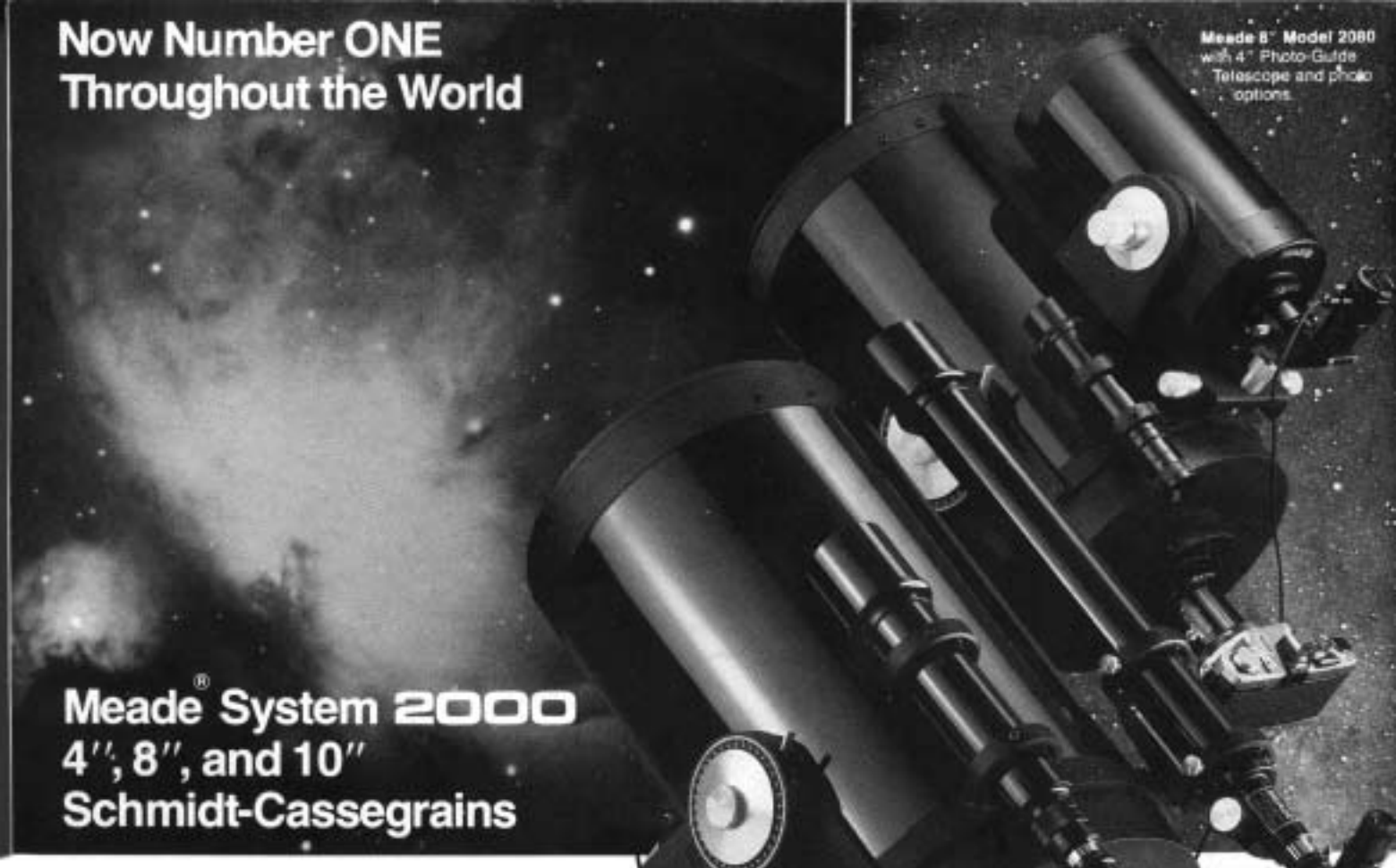
P. O. Box 3125
Richmond, Virginia 23235
United States of America

Monday–Saturday
9 A.M. – 9 P.M. E.S.T.
☎ (804) 320-7016

Serving Astronomers Worldwide

Since 1973

Now Number ONE Throughout the World



Meade 8" Model 2080 with 4" Photo-Guide Telescope and photo options

Meade® System 2000 4", 8", and 10" Schmidt-Cassegrains

Meade 4", 8", and 10" Schmidt-Cassegrains are now the leading choice of serious amateur astronomers throughout the world. And little wonder. Consider the listing of **standard** features on Meade 8" and 10" models—features that have made competing Schmidt-Cassegrains obsolete by comparison:

- Worm-gear, photo-precision drive systems.
- Computer-optimized optical and light-baffle designs which produce, aperture-for-aperture, 10% brighter off-center images than competing Schmidt-Cassegrains.
- The finest diffraction-limited optics, polished to accuracies within 1/10-wavelength or better.
- The most stable tripod and wedge systems available.

Prices: Meade Schmidt-Cassegrains are very competitively priced, even compared to other telescopes offering far fewer features. Contact your Meade mail-order or local showroom dealer for his best prices.

52-page General Catalog #83-M and Astrophoto Brochure: $3.00 (Outside North America $5.00 for air mail.)

Meade Bulletin 800: "A Frank Technical Comparison of Commercially Available Schmidt-Cassegrains," free for the asking.

Meade 10" Model 2120 with optional 2" f/12 Photo-Guide Telescope

Meade Instruments Corporation
1675 Toronto Way
Costa Mesa
California 92626
(714) 556-2291

Background photos: (left) The Orion Nebula; Meade 2080, by Leo Henzl. (right) The Milky Way in Sagittarius; piggyback Model 2080 photo by Emery Hildebrand.

AUTHORIZED INTERNATIONAL DISTRIBUTORS

France
Devaux Chevet S.A.
35, Rue de Rivoli
75004 Paris, France

Medas S.A.
57, Avenue Prés. Doumer
B.P. 181
03206 Vichy, France

Switzerland
E. Aeppli/Spiegeloptiken
Loowiesenstrasse 60
CH-8106 Adlikon
Switzerland

Italy
Ottica Miotti
Corso XXII Marzo, 32
20135 Milan, Italy

Japan
MIC International Corp.
Hoshino Bldg.
7-20, Toranomon, 3-chome
Minato-ku, Tokyo, 105 Japan

West Germany, Austria
Kosmos Service-71
Postfach 640, Pfizerstrasse 5-7
7000 Stuttgart 1
West Germany

Belgium, Netherlands
O.P.-Slotte
Chaussée D'Alsemberg 59
1060 Brussels, Belgium

Australia
Science World
138 Railway Parade
Leederville, 6007,
Perth, Western Australia

Spain
IMVO/R. Roure Codoñer
C/Col. Legi n. 24
(Bordeta) Lleida, Spain

Sweden, Denmark, Norway
AB G Wendelholm
Box 14069 S- 10440
Stockholm, Sweden

Taiwan
B & E Optical Co., Ltd.
P.O. Box 84-621
Taipei, Taiwan

Portugal
Contabilex
Av. 25 de Abril, 13-1°
2750 Cascais
Portugal